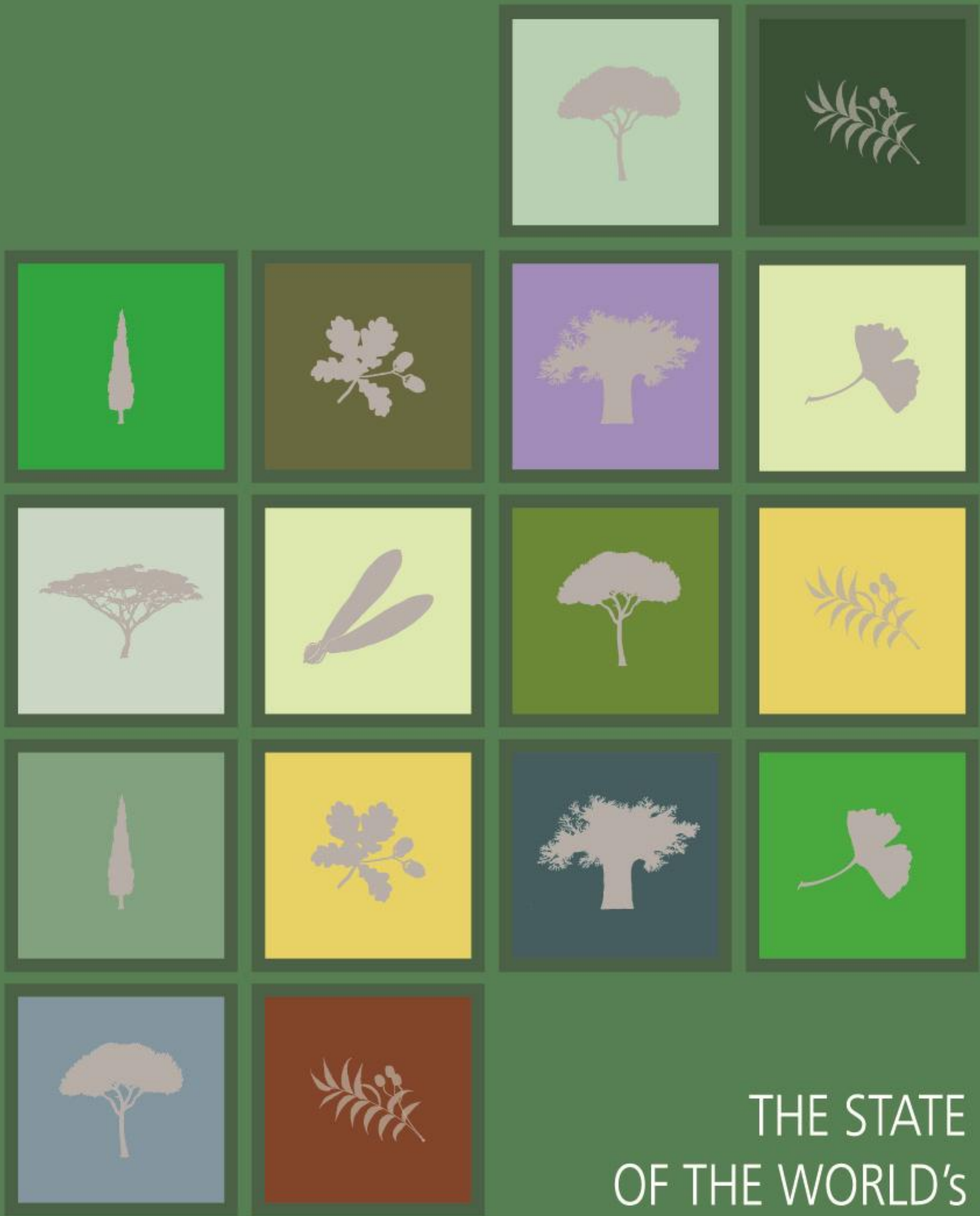


THE STATE
OF THE WORLD's
FOREST GENETIC RESOURCES
COUNTRY REPORT
THAILAND

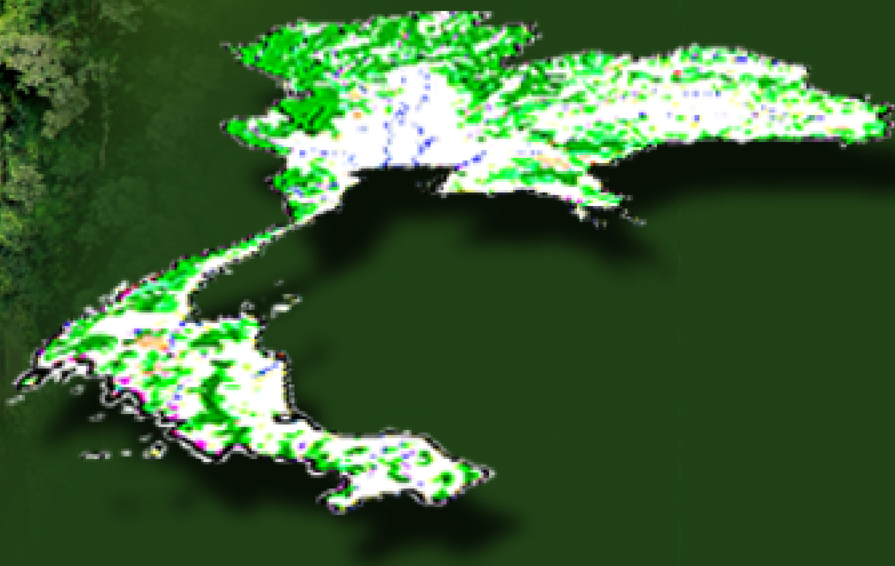
This country report is prepared as a contribution to the FAO publication, The Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document Guidelines for Preparation of Country Reports for the State of the World's Forest Genetic Resources (2010). These guidelines set out recommendations for the objective, scope and structure of the country reports. Countries were requested to consider the current state of knowledge of forest genetic diversity, including:

- Between and within species diversity
- List of priority species; their roles and values and importance
- List of threatened/endangered species
- Threats, opportunities and challenges for the conservation, use and development of forest genetic resources

These reports were submitted to FAO as official government documents. The report is presented on www. fao.org/documents as supportive and contextual information to be used in conjunction with other documentation on world forest genetic resources.

Country Report

On Forest Genetic Resources Of Thailand



Changtragoon, S.[1], Ongprasert, P.[2], Tangmitcharoen, S.[2], Diloksampan, S.[3], Luangviriyasaeng, V.[2], Sornsathapornkul, P.[1] and Pattanakiat, S.[4]

[1]Department of National Parks, Wildlife and Plant Conservation
in collaboration with
[2]Royal Forest Department, [3]Kasetsart University and [4]Mahidol University

COUNTRY REPORT

On Forest Genetic Resources of Thailand

By

Changtragoon, S. [1], Ongprasert, P. [2], Tangmitcharoen, S. [2], Diloksampan, S. [3], Luangviriyasaeng, V. [2], Sornsathapornkul, P. [1] and Pattanakiat, S. [4]

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List of Acronyms

AAU	University of Aarhus
ABS	Access and Benefit-Sharing
ACIAR	Australian Center for International Agricultural Research
ADB	Asian Development Bank
AFD	French Development Agency
AFLP	Amplified Fragment Length Polymorphism
AIFS	ASEAN Integrated Food Security Framework
APAFRI	Asia Pacific Association of Forestry Research Institutions
APFORGEN	Asia Pacific Forest Genetic Resources Program
APFSOS IIWP	Asia-Pacific Forestry Sector Outlook Study II Working Paper
ASEAN	Association of Southeast Asian Nations
ASEAN-FAO	Association of Southeast Asian Nation - Food and Agriculture Organization
ASEAN-WEN	Association of Southeast Asian Nation - Wildlife Enforcement Network
AusAID	Australian Agency for International Development
AWG	Ad Hoc Working Group
AWG-LCA	Ad Hoc Working Group on Long-term Cooperative Action Under the Convention
BEDO	Biodiversity based Economy Development Office
BGO	Botanical Garden Organization
BIO-REFOR	Biotechnology Assisted Reforestation Project
BIOTEC	National Center for Genetic Engineering and Biotechnology
BK	Bangkok Herbarium, Department of Agriculture
BKF	Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation
BRT	Biodiversity Research and Training Program
BSC	Biological Species Concept
C	University of Copenhagen
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CEP-BCI	Core Environment Program and Biodiversity Conservation Corridors Initiative
CFC	Common Fund for Commodities
CIDA	Canadian International Development Agency
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cpSSR	Chloroplast Simple Sequence Repeat
CR	Critically Endangered
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSR	Corporate Social Responsibility
DANCED	Danish Co-operation for Environment and Development
DANIDA	Danish International Development Agency
DBH	Diameter at Breast Height
DD	Data Deficient
DFID	Department for International Development
DFSC	Danish Forest Seed Center

DMCR	Department of Marine and Coastal Resources
DNA	Deoxyribonucleic acid
DNP	Department of National Parks, Wildlife and Plant Conservation
E	Royal Botanic Garden, Edinburgh
EN	Endangered
EU	European Union
FAO	Food and Agriculture Organization
FCPF	Forest Carbon Partnership Facility
FFEM	French Global Environment Facility
FINNIDA	Finnish International Development Agency
FIO	Forest Industry Organization
FORGENMAP	Forest Genetic Resources Conservation and Management Project
FORSPA	Forestry Research Support Program for Asia and the Pacific
FRC	Forest Research Center
FRIM	Forest Research Institute Malaysia
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GMS-BCI	Greater Mekong Subregion Biodiversity Cooridor Initiative
GPI	Global Plant Initiative
GTI	Global Taxonomy Initiative
GTZ	German Society for Technical Cooperation
Ha	Hectare
H_e	Expected Heterozygosity
IBPGR	International Board for Plant Genetic Resources
INBAR	International Network for Bamboo and Rattan
IPGRI-APO	International Plant Genetic Resources Institute, Regional Office for Asia, the Pacific and Oceania
IS	Identified Stand
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forest Research Organizations
IYB	International Year of Biodiversity
KEW	Kew Garden,The Royal Botanic Gardens
KU	Kasetsart University
KUFF	Faculty of Forestry at Kasetsart University
KURDI	Kasetsart University Research and Development Institute
KYO	University of Kyoto
L	National Herbarium Nederland, Leiden
Lao-PDR	The Lao People's Democratic Republic
M	Muenchen
MAT	Mutually Agreed Terms
MCPA	Marine and Coastal Protected Areas
MEE	Management Effectiveness Evaluation
MFF	Mangroves for the Future
MNRE	Ministry of Natural Resource and Environment
MOAC	Ministry of Agriculture and Cooperatives
MP	Multipurpose Tree Improvement Program
MPA	Marine Protected Area
MRV	Monitoring, Reporting and Verification

MTA	Material Transfer Agreement
NESDB	National Economic and Social Development Board
NESDP	National Economic and Social Development Plan
NGO	Non - Government Organization
NIR	Near Infrared Reflectance
NRCT	National Research Council of Thailand
nSSR	Nucleus Simple Sequence Repeat
NTFP	Non-Timber Forest Products
NWFP	Non -Wood Forest Product
OECD	Organization for Economic Co-operation and Development
OEPP	Office of Environmental Policy and Planning
ONEP	Office of Natural Resources and Environmental Policy and Planning
P	Muséum National d' Histoire Naturelle, Paris
PA	Protected Area
PES	Payment for Environmental Services
PIC	Prior Informed Consent
PPFC	Phatam Protected Forests Complex
PSS	Provenance Seed Stand
R-PIN	Readiness Plan Idea Note
R & D	Research and Development
Ramsar	The Convention on Wetlands of International Importance Especially as Waterfowl Habitat
RAPD	Random Amplified Polymorphic DNA
RECOFTC	Regional Community Forestry Training Center for Asia and the Pacific
REDD	Reducing Emission from Deforestation and Degradation in Developing Country
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries ; and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries
RFD	Royal Forest Department
RIO	Rio de Janeiro, Brazil
SBSTA	Subsidiary Body for Scientific and Technological Advice
SCZ	Seed Collection Zone or Ecozone
SE	Southeast
SEA	South-East Asia
SEFUT	Socio-Economics of Forest Use in the Tropics and Subtropics
SING	Singapor Herbarium
SO	Seed Orchard
SPA	Seed Production Area
SS	Selection Stand
SSR	Simple Sequence Repeat
TAO	Tambon Administration Organization
TBCA	Trans-Boundary Biodiversity Conservation Area
TCD	Trinity College
TEAKNET	International Teak Information Network
TEEB	The Economics of Ecosystems and Biodiversity
Thai- WEN	Thailand's Wildlife Enforcement Network

TIC	Teak Improvement Center
TISTR	Thailand Institute of Scientific and Technological Research
TPC	Thai Plywood Company
TRF	Thailand Research Fund
TROF	Tree Resources Outside Forests
UFZ	Helmholtz Center for Environmental Research
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNGA	United Nations General Assembly
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
VU	Vulnerable
WB	World Bank
WEFCOM	Western Forest Complex
WWF	World Wide Fund for Nature

Executive summary

Forest resources are vital to humans as a source of food, raw materials and a variety of products and services. Forest areas in Thailand have gradually declined, but were relatively stable in the 1990s due to strong measures implemented by the Thai Government. These measures included a ban on logging and an expansion of the area of conservation forests. With an increase in public awareness and in the efforts of responsible agencies, forest areas have been maintained at 17,218,429 ha (172,184.29 km^2). This accounted for 33.56% of the total land area in 2009, which is 6.44% behind the goal of 40% land area targeted nationally for expected forest areas in the country.

Current State of Forest Genetic Resources

In Thailand, there are 10 main forest types, namely Moist Evergreen Forest, Dry Evergreen Forest, Hill Evergreen Forest, Pine Forest, Peat Swamp Forest, Mangrove Forest, Beach Forest, Mixed Deciduous Forest, Dry Dipterocarp Forest and Bamboo Forest. The dominant tree species differ in each forest type. Some dominant forest tree species are characterized by seed sources and provenance zones in different regions of Thailand. A number of major of economically and ecologically important forest trees and wild plants such as *Pinus merkusii* Jungh. & de Vriese, teak (*Tectona grandis* L.f.), *Dipterocarpus alatus* Roxb. Ex G.Don, *Rhizophora apiculata* Blume, *R. mucronata* Poir, *Bambusa bambos* (L.) Voss and wild orchid (*Paphiopedium exul* (Ridl.)) were investigated for their genetic diversity and mating systems using allozyme gene and molecular makers. The information provided could be used to establish criteria for gene conservation and reforestation programs of these species. It was reported that 340 forest trees and native species are threatened, especially siamese rosewood (*Dalbergia cochinchinensis* Pierre). Therefore, priority tree species were listed based on different categories namely economic, fuel wood, rehabilitation, rare and endangered species and non-wood forest products. Siamese rosewood was identified both as an economically important endangered trees species.

In 1961, nearly 53% of the total land area in Thailand was forested. However, owing to an increasing emphasis on agricultural and economic development, coupled with population growth, the natural forest biological resources have steadily declined. In 1985, Thailand’s national forest policy set the goal to have 40% of the nation’s geographical area under forest, with nearly 25 % comprising conserved forest and 15 % economic forest. Based on remote sensed imaging during 2009, the Department of National Parks, Wildlife and Plant Conservation (DNP) and the Royal Forest Department (RFD) reported forest cover of 33.56%. Therefore, genetic erosion in some forest tree species was observed and investigated. The trends in threat and risk disaster analysis for forest genetic resources have been established in forest areas and ecosystems for some time, but analysis of threats and the capacity to respond to threats still need to be strengthened.

Therefore, country needs and priorities to improve forest genetic resources disaster response mechanisms require a holistic policy and management approach across relevant ministries on human, natural resources and environmental dimensions. This will entail instituting zoning of land uses for forest conservation and protected areas zoning for proper agricultural land use and zoning for other sectors. Public awareness and participation must be increased for zoning to be effective.

The country priorities to improve monitoring of genetic erosion and vulnerability and to improve the response to observed erosion and vulnerability are as following: 1) Long term genetic diversity assessment in priority and targeted species; 2) Long term satellite and inventory survey of forest cover change and Geographic Information System (GIS) mapping of endangered and priority species; 3) Long term biodiversity surveying by enhancing local community participation; and 4) Public awareness and participation on the values of biodiversity and sustainable use.

In order to improve our understanding of the state of diversity of forest genetic resources and biodiversity, priority must be placed on increasing manpower and building capacity for conducting research. Critical areas requiring strengthening include estimates of genetic diversity, surveys of ecosystem abundance and natural regeneration, and surveys of habitat loss. Better ways must be found to assess genetic erosion and provide an understanding of its causes. Socio-economic studies of the livelihood of local communities and research on economic investment related to natural products are needed as well. Overall, the priorities should be to better understand the roles and value of the diversity of forest genetic resources economically, socially, culturally and ecologically.

In order to establish a strategic direction relevant to improving understanding of the state of forest genetic diversity and maintaining this diversity, a national committee on forest genetic resources and a master plan should be developed. Both top down and bottom up approaches should be initiated. The country report on forest genetic resources will help on drawing the attention of policy makers to the importance and critical status of forest genetic resources. A national forest genetic resources strategic action plan should be set up through relevant stakeholder consultations. During the process, knowledge about forest genetic resources and public awareness should be transferred to all levels of stakeholders. Therefore, research, projects and relevant activities should be identified for all aspects related to conservation, protection and sustainable use of forest genetic resources. Estimates of genetic diversity and erosion are especially important to use as criteria and guidance for proper, efficient forest genetic resources management. At the regional level, Thailand is in a good position to serve as a hub for assessment of genetic diversity of forest trees resources in the Lower Greater Mekong Sub-region and beyond, since the DNP has an excellent facility in its Deoxyribonucleic acid (DNA) and Isoenzyme Laboratory. Therefore, research projects and networking among countries should be established and supported by international organizations and initiatives. National, regional and global interventions are required.

The State of *in situ* Genetic Conservation

Generally, *in situ* conservation implies the continuing maintenance of a population within the environment where it originally evolved, and to which it is adapted. *In situ* conservation can have different purposes but, in this report it refers to genetic conservation. *In situ* conservation includes protected areas that are established for other conservation purposes and that also provide protection for genetic resources. In Thailand, current *in situ* genetic conservation can be classified into three categories: *in situ* genetic conservation within protected areas; *in situ* genetic conservation of target species; and *in situ* ecosystem genetic conservation. Forest genetic resources are generally well-preserved in protected areas due to strict laws and regulations.

Thailand has long been involved with *in situ* conservation of forest genetic resources. Intensive activities on *in situ* conservation were initiated with lowland source *Pinus merkusii* Jungh. & de Vriese since 1977 where natural stands, especially in the northeast of Thailand, have been heavily exploited. Eight genecological zones were identified, natural stands in each zone were selected and conservation measures and management options proposed specifically for each zone. Teak is also considered to be a very important tree species for *in situ* conservation of genetic resources in Thailand, since teak forests have already suffered severely from overexploitation and conversion to land. Similar to *P. merkusii* Jungh. & de Vriese, a survey of natural teak forests was undertaken in 1995 in which fragments of original teak forests were found mainly in seven national parks in the northern part of Thailand. The density of reproductive teak trees in each national park has also been surveyed intensively. As a result five genecological zones for the remaining natural teak in Thailand have been identified, along with proposed measures and implementing activities for *in situ* conservation in 15 locations covering all genecological zones. However, only three locations of teak natural stands were later selected for *in situ* ecosystem conservation together with 12 locations of other forest types.

With the support of the Royal Danish Government, Thailand initiated *in situ* conservation of forest genetic resources in 1970s. As a result, a substantial amount of know-how in the improvement of economically important tree species was obtained during the past four decades. In addition, national policies and measures, such as the Tenth National Economic and Social Development Board Plan 2007-2011 and the national policy on the Convention on Biological Diversity (CBD) emphasize conservation and management of forest genetic resources, including *in situ* conservation. Nevertheless, the government reorganization in accordance with the Government Body Restructuring Act 2002 which divided the RFD into three bodies: the RFD, the DNP and the Department of Marine and Coastal Resources (DMCR) has hindered some action plans and/or operating activities related to conservation of forest genetic resources during the transfer of the duties and responsibilities among the key departments. National priorities for future *in situ* genetic conservation actions in Thailand include: promotion of the natural regeneration of the existing conservation areas; establishment of effective local awareness and support for community efforts toward conservation and sustainable management of existing *in situ* conservation areas; and expansion of *in situ* conservation of genetic resources of individual priority species. Top priority species for genetic resources conservation are identified based on economic and ecological importance: siamese rosewood; *Afzelia xylocarpa* (Kurz) Craib; *Dipterocarpus alatus* Roxb. ex G.Don; *Hopea odorata* Roxb.; *Pterocarpus macrocarpus* Kurz *and* teak. Research needs that provide more confident information about these individual species are identified for future management of *in situ* genetic conservation in Thailand.

The State of *ex situ* Genetic Conservation

In general, *ex situ* genetic conservation in Thailand has been more or less well developed and managed. We directly and continually engage in *ex situ* genetic conservation in the form of field conservation for experimental purposes, creating storage of genetic diversity, educational and recreational purposes through tree improvement programs (provenance trials, progeny tests, seed orchards) and plantation plots *i.e.* gene conservation, spacing trials, arboreta, botanical gardens. A substantial amount of know-how in the improvement of economically important tree species has been obtained during the past four decades with the assistance of the Royal Danish Government. The tree improvement and seed sources of many economic tree species including teak, pines and some hardwoods have been conserved and developed. Plus trees of 70 species have been selected for use as a source for additional improved germplasm for the future.

However, when focusing on the species, a holistic action plan has not yet been developed. This could be the greatest constraint to improve *ex situ* genetic conservation. It is, therefore, highly recommended that both short-term and long-term strategies for *ex situ* genetic conservation of the top priority species need to be systematically developed to set up new *ex-situ* plots and follow-up the previous works.

Use and Sustainable Management of Forest Genetic Resources

The management of forest genetic resources in Thailand was developed beginning in 1960. The indigenous species (teak, tropical pine, *Pterocarpus macrocarpus* Kurz, siamese rosewood, *Phyllanthus emblica* L.) and exotic species (*Eucalyptus* spp., *Acacia* spp., exotic tropical pine and *Casuarina junghuniana* Miq.) are the main species for improvement programs. *Gluta usitata* (Wall.) Ding Hou and *Aquilaria* spp. have been domesticated for non-wood products. Seed and others propagation materials from improvement programs have been released to plantations. Capacity-building for genetic resource management is needed to sustainably use and manage forest genetic resources in Thailand. A regional breeding network of common species in the region will be effective for genetic resource management to save cost and to time.

The State of National Programs, Research, Education, Training and Legislation

Forestry research in Thailand started ten years before the RFD was founded in 1896 in order to develop knowledge on the extent of teak resources. For the early decades, research emphasized the management of natural forests. Four lac regional silvicultural research stations were later established in 1952, and others were added subsequently. The Teak Improvement Center in Lampang and the Tree Improvement Center in Chiang Mai were established with the support from Danish government. Four research stations were also established. Some collaborative research projects were carried out with the support of a number of developed countries and international organizations. These research efforts represented a major public sector investment in forest development.

After reconstructing the RFD in 2002, there were forest research offices under the RFD, the DNP and the DMCR as the 3 major forest-related departments under the Ministry of Natural Resources and Environment (MNRE). The DNP concentrates on forest conservation research and biodiversity surveys, while RFD research mainly focuses on *ex situ* conservation and utilization of forest genetic resources. The DMCR specializes in natural resources research in marine and coastal habitats. Even though a forest research institute has been planned and discussed among relevant departments to be established as a center for serving all aspects of forest research and enhancing multi-disciplinary research and extension, so far this goal has not been achieved. Therefore, this effort should be further developed in order to fill in gaps and enhance harmonization and capacity-building in all aspects of research on forest genetic resources. This effort should be in line with national policy and should address hot issues related to regional problems and concerns, as well as relevant conventions such as CBD, United Nations Framework Convention on Climate Change (UNFCCC) and Convention on International Trade in Endangered Species (CITES). In order to fulfill these goals, international collaboration and networks on forest genetic research should be established at national, regional and global levels.

However, the DNP, RFD and DMCR should promote national conservation and sustainable use of forest genetic resources holistically. A long-term research fund should be established to provide a robust database and predict the trends of change of forest genetic resources and forest types including new species. The establishment of a database system, appropriate amendment of laws and continuity of public awareness informational campaigns on protection and conservation of forest genetic resources at all education and community levels could fulfill the achievement of this effort.

The State of Regional and International Collaboration

To improve the effectiveness of international collaboration regarding forest genetic resource conservation and management, the needs and priorities for the promotion and improvement of international collaboration are considered to be ranked as following: 1) understanding the state of diversity; 2) enhancing *in situ* conservation and management; 3) enhancing *ex situ* conservation and management; 4) enhancing the use of forest genetic resources; 5) enhancing research; 6) enhancing education and training; 7) enhancing legislation; and 8) enhancing information management and early warning systems for forest genetic resources. If sufficient financial support from international organizations was provided, all the activities mentioned above could be jointly conducted in the same project by carefully choosing priority species and hot spot ecosystems.

Meanwhile, Thailand’s development vision has increasingly emphasized the social dimension in order to cope with the effects of globalization. The country needs to integrate the problems of global warming, biodiversity deterioration, desertification and other international commitments to protect natural resources such as CITES into the policy in order to plan for sustainable national development. Sustainably incorporating international environmental phenomena is a new challenge for the Thai Government as it pursues the country’s sustainable development.

Access to Forest Genetic Resources and Sharing of Benefits Arising From Their Use

Thailand is a party to the Convention on Biological Diversity and has already signed the Nagoya Protocol on access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization. At the national level, the **Regulation of the National Committee on Biodiversity Conservation and Utilization on Criteria and Approaches of Access to Genetic Resources and Benefit Sharing from Their Use B.E. 2554 (2011)** has been declared to support and provide guidance for the implementation of access to genetic resources and benefit-sharing derived from these resources. In terms of access to forest genetic resources, the main organizations, including the DNP, the RFD and DMCR developed relevant regulations that provide conditional access to forest genetic resources due to their owns laws and regulations. With regard to benefit-sharing, no clear regulations have been promulgated by governmental organizations. However, based on Plant Variety Protection Act B.E. 2542 (1999), a mechanism of MAT of benefit-sharing arising from use of wild plants for commercial purposes has been developed through the establishment of the Plant Variety Protection Fund. In addition, some organizations such as TISTR, BIOTEC or BGO possess forest genetic materials and developed their own rules and regulations relevant to access and benefit-sharing of collected forest genetic materials in form of MTA. At this stage, it may be foreseen that, even though Thailand has signed the Nagoya Protocol, either the issuance of new laws and regulations or revision of existing laws and regulations will be necessary to fully support and facilitate the access to forest genetic resources and benefit-sharing from its utilization.

The Contribution of Forest Genetic Resources to Food Security, Poverty Alleviation and Sustainable Development

Forests cover approximately 30% of the global surface and provide food, medicines, fuel and other basic necessities to approximately 1.6 billion people across the world. As a consequence, forest resources have been heavily utilized to serve people who depend in their daily lives on the products gathered from the forests. Poverty is then counted as the most significant cause of deforestation and loss of biodiversity. However, the genetic resources of forests have a high economic potential for providing for material needs, for cash income and for the employment for local inhabitants. These resources can help alleviate rural poverty. One approach that has been well accepted worldwide as a “pro poor” strategy for promoting sustainable forest management is community forestry. The approach proposes many activities such as agro-forestry to secure food while helping to alleviate poverty across the world. In order to attain sustainability of genetic resource conservation, community forestry programs would be a possibly alternative approach to achieve the objective. In addition to the direct benefits from forest products, indirect benefit will also be derived from the genetic resource pool. Activities like ecotourism, which has become more popular among nature-lovers, can be counted in this case. Since ecotourism involves travelling to natural areas for natural study as well as admiring beauty of scenic areas while improving welfare of local inhabitants. Therefore, the role of subdistrict administration agency on forest genetic conservation should be strengthened.

Introduction to the Country and Forest Sector

General background and information of Thailand

The Kingdom of Thailand is located in Southeast Asia (Figure 1), between latitudes 50^{0} 35' - 20^{0} 15' North and longitudes 97^{0} 30' - 105^{0} 45' East. Total area is 51,311,500 ha (513,115 km^{2}). Mountainous areas in the northern part of the country are the source of headwaters of the nation's most important river, the Chao Phraya. A plateau in the northeast runs eastward to the Mekong River and acts as a natural border with the Lao People's Democratic Republic. The long peninsula of southern Thailand separates the South China Sea in the east and Andaman Sea in the west.

Figure 1 Map of Thailand
Source: UN Cartographic Section (2004)

Its climate is tropical, dominated by the southwest monsoon from May to October, which brings high rainfall and humidity to the region. Average annual rainfall ranges from 1,250 mm in the northeast to more than 4,000 mm in the southern peninsula. A dry season runs from November to April, with relatively cool temperatures until February. March through May is dry and hot. Average annual temperature is 28.9^{0} C.

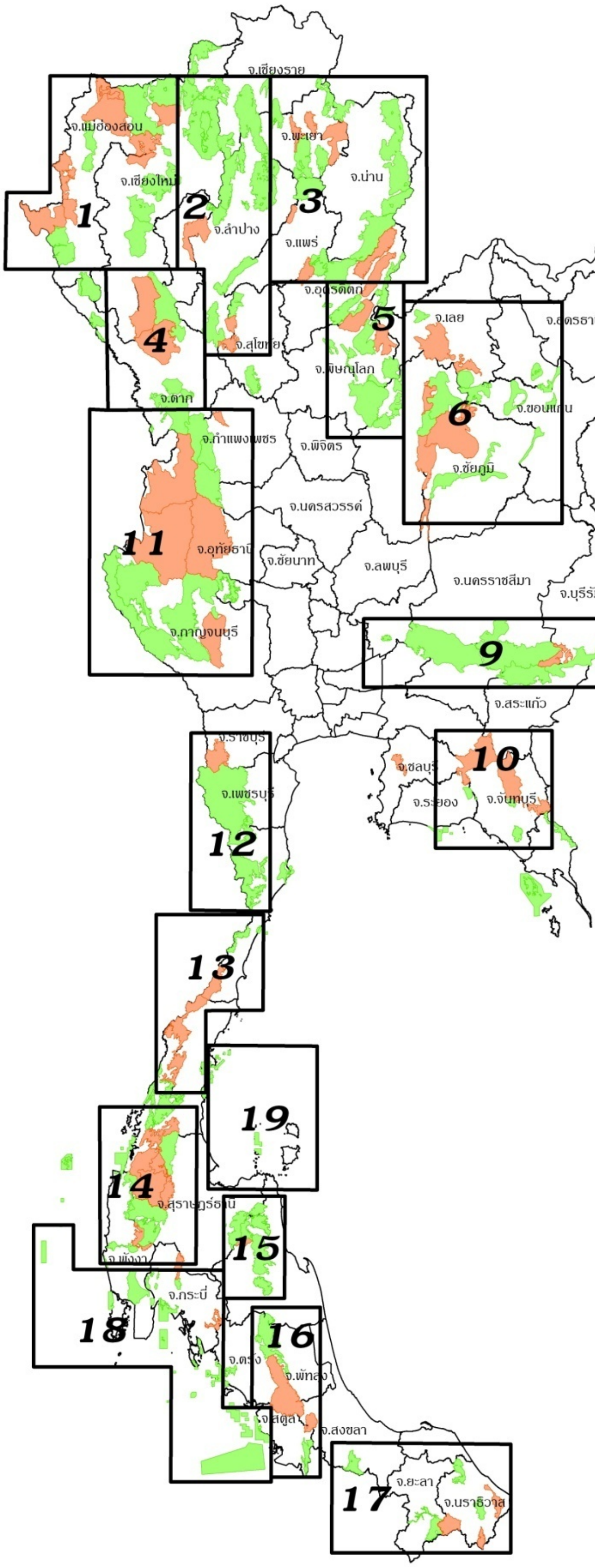
In 1961, the population of Thailand was recorded as 30 million, compared with 65.4 million in 2010. Annual growth rate at present is 0.6 %. Both birth rate and death rate is 12 and 6.5 per 1,000 population respectively. Population density in whole Kingdom is approximately 127.5 people/km^2 with 29.9 million persons live in municipal areas and 35.5 million persons in non-municipal areas (National Statistical Office, 2012).

A brief profile of forest sector

Forest area and resource

According to the Forest Act B.E. 2484 (1941), “forest” is officially defined as land that has not been taken up or acquired by any other means in relation to land law. Forests and forestland are state property and the responsibility of three departments in the Ministry of Natural Resources and Environment (MNRE); i.e. the Royal Forest Department (RFD), the Department of National Parks, Wildlife and Plant Conservation (DNP), and the Department of Marine and Coastal Resources (DMCR). In 1961, the total forest area of Thailand was about 27 million hectares covering over 53.3 percent of the country. Subsequently, forest areas were encroached for the purpose of slash-and-burn practices , shifting cultivation, resettlement, infrastructure development like dam and road construction, land reform for agriculture, etc. As a result, the share of forest area declined to 25.3 percent in 1998. From 2000 onwards, the forest has been assessed from LANDSAT-5 interpretation imageries at a scale of 1:50,000, while earlier assessments were made using imageries of 1:250,000. Due to the change of scale and method of calculation a new benchmark was established for forest area. The annual rate of deforestation has been about 63,000 ha (630 km^2) per year since 2000, or higher than in the 1990s. Based on DNP (2010a). It is reported that the forest cover area in 2009 was 33.56 percent of the total area of the country. Regarding to forest ecosystem management, forest in Thailand was grouped into 19 forest complexes as shown in Figure 2.

Given Thailand’s variable climate and topography, Santisuk (2007) describes Thailand’s forests as a complex mosaic of dry open deciduous, evergreen. There are two main forest types in Thailand: (1) Evergreen Forest and (2) Deciduous Forest.



List of forest complexes

1. Lum Num Pai – Salawin Forest complex
2. Sri Lanna - Khun Tan Forest complex
3. Doi Phu Kha - Mae Yom Forest complex
4. Mae Ping - Om Koi Forest complex
5. Phu Mieng - Phu Thong Forest complex
6. Phu Khieo - Nam Nao Forest complex
7. Phu Phan Forest complex
8. Phanom Dongrak-Pha Tam Forest complex
9. Dong Phayayen - Khao Yai Forest complex
10. Eastern Forest complex
11. Western or WEFCOM Forest complex
12. Khang Krachan Forest complex
13. Chumphon Forest complex
14. Khlong Saeng - Khao Sok Forest complex
15. Khao Luang Forest complex
16. Khao Banthad Forest complex
17. Hala-Bala Forest complex
18. Mu Ko Similan-Phi Phi-Andaman
19. Mu Ko Ang Thong – Ao Thai

National Park

Wildlife Sanctuary

Figure 2 Main forest complexes of Thailand

Source: DNP (2009a)

Evergreen forest

The Evergreen Forest is subdivided into Tropical Evergreen Forest, Pine Forest, Mangrove Forest and Beach Forest. Tropical Evergreen Forest is found in high humidity areas of the country. This type of forest is also subdivided into 3 types namely Moist Evergreen Forest, Dry Evergreen Forest and the Hill Evergreen forest. Moist Evergreen Forest characterized by very rich flora, is found in the eastern regions where rainfall is over 2,000 mm. It is also found along rivers and/or in valleys in other parts of the country. The emergent species belonging to the genus, *Dipterocarpus*, *Hopea*, *Shorea*, *Vatica* and *Syzygium*, whereas the lower storey species are bamboos, palms and rattans.

Dry Evergreen Forest is scattered all over the country where the rainfall is between 1,500 – 2,200 mm. The emergent species belong to the genus *Dipterocarpus*, *Hopea*, *Hydnocarpus*. The dominant undergrowth species consist of bamboo (*Bambusa*, *Gigantochloa*) and rattan (Calamus). Hill Evergreen Forest is found on the mountainous areas (over 1,000 meters from mean sea level) where the climatic condition is the humid subtropical type. The presence of mosses and lichens on trees and rocks is an indicator of this forest type. The dominant species belong to genus oaks - *Quercus*, *Castanopsis* and *Lithocarpus*. The tropical pine forest has two species, *Pinus merkusii* Jungh & de Vriese, locally called Son Song Bai (the two-needle pine), and *P. kesiya* Royle ex Gordon, locally called Son Sam Bai (the three-needle pine). *P. merkusii* Jungh & de Vriese is found in the northern, north-eastern and western parts of the central region where the soil is poor,i.e. lateritic and podzolic. *P. kesiya* Royle ex Gordon is found only in the highlands of the northern and northeastern region.

Deciduous forest

Deciduous forest is characterized by the presence of deciduous tree species and is commonly found throughout the country. It is broadly subdivided according to the species composition into the mixed deciduous forest (with and without teak (*Tectona grandis* L.f.)) and the dry deciduous dipterocarp forest. In particular, this type of forest can be classified as mixed deciduous forest which is commercially among the most valuable forest of Thailand. In the northern region, this type of forest is called the teak forest with teak, *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen , *Pterocarpus marcrocarpus* Kurz, *Afzelia xylocarpa* (Kurz) Crian and *Dalbergia* spp. (rose wood) as dominant/common species. Another type is dry deciduous dipterocarp forest that is commonly found in the dry area (rainfall below 1,000 mm.) with sandy or gravelly lateritic fertile soils. The dominant species are mainly deciduous Dipterocarpaceae such as *Dipterocarpus tuberculatus* Roxb., *D.intricatus* Dyer, *Shorea obtusa* Wall. ex Blume, *S. siamensis* Miq. with the presence of *Dalbergia* spp., *Diospyros* spp., *Terminalia* spp. and other species. (Rasmussen *et al.*, 2002)

Biodiversity Conservation

Thailand is bestowed with rich floral, faunal and cultural diversities. It contains approximately 7 percent of the world's flora and fauna. It is considered a collective center of botanical diversity from major regional elements: Indo-Burmese, Indo-Chinese and Malaysian.

There are approximately 15,000 plant species in the country of which approximately 12,000 are vascular plant species, including over 1,140 species of orchids. There are more than 2,154 non-vascular plant species in Thailand, including algae and bryophytes, i.e. moss, hornwort, and liverwort. (Office of Natural Resources and Environmental Policy and Planning [ONEP], 2009a)

Thailand has approximately 4,591 species of vertebrates and about 83,000 invertebrate species, of which 14,000 species can be identified. Most of the identified species are insects. Many plant and animal species are endangered, rare or threatened while many species have also been domesticated. (ONEP, 2009a)

Timber production, imports and exports

Before the logging ban in 1989, timber production was about 2 million m^3 per year, sufficient for national consumption and export. Since that time, however, especially in the 1990s during Thailand's economic development, the supply of hardwood falls short of domestic demand, as does the demand for other industrial wood products (e.g., sawn-timber, plywood, veneer sheets, wood panels, and particle board). Although some timber is available from forests that are cleared for infrastructure development (e.g., roads and dams) or from the confiscation of illegal logs, forest plantations are another source, as well as rubber wood from old plantations. By 2009, Thai traders imported 1.4 million m^3 of logs and sawn-timber from more than 50 countries to satisfy domestic demand, mainly from Congo Republic, Malaysia, and Papua New Guinea. Thailand exported 2.8 million m^3 of sawn-wood, particleboard and fiberboard to 19 countries, mainly Denmark and Malaysia (RFD, 2010). In particular, most of the total sawn-wood exports were rubber-wood from old rubber plantations. Rubber-wood was found to export to Peninsular Malaysia which has been suffering from a shortage of sawn rubber-wood (Food and Agriculture Organization [FAO], 2009).

Deforestation and forest encroachment

Forest resources provide a multitude of goods and services, including pulp, timber, Non-Wood Forest Products (NWFP), medicinal and edible plants, as well as other raw materials such as rattan and bamboo. More than 1,000 recorded species of plants contain medical properties and 30,000-40,000 households harvest them on a full-time basis. Furthermore, 60% of the rural population or roughly 30,000 communities living near forests rely on edible plants for their daily needs and more than 500 species of these plants are sold in local markets throughout the country (Brenner *et al*., 1999).

In terms of trade, Thailand has a long history of using its forests for commercial purposes, dating back to the mid-19th century when the first logging concessions of teak were issued to private enterprises. The removal of mature timber stands allowed immigrants and forest dwellers to settle. However, the drivers of deforestation shifted in the 1980s when rapid economic growth replaced subsistence crops with cash crops. In 1989, alarmed by the high conversion rate of forestland, the government revoked all terrestrial concessions by decree. However, the logging ban was not enough to bring forest loss to a halt. Currently, decreases in forest area are mainly due to agricultural expansion, other land uses, intensified swidden activities, and poaching.

Currently, more than 1 million households are living within Thailand’s National Forest Reserves. The forest dwellers depend on the forest mainly for NWFPs and as a safety net in times of hardship. The forests also provide a source of cash income, a capital asset and employment. Deforestation and forest encroachment decreased noticeably after the Royal Thai Government imposed a logging ban in 1989 and began to protect forests. Rural poor people and owners of land bordering natural forests who tried to expand their farms into those areas have been accused of deforestation and encroachment. Some argue that, with no visible signage, it is difficult to identify the boundary of the reserved forest. In addition, the tribes and minority ethnic Thais who live in the mountainous areas consider slash and burn practices a traditional way of life, mostly in catchment areas in the north and northeast. This practice affects soil fertility upstream and water quality downstream. The RFD and other agencies, especially through the Royal Initiative Project, have tried to mitigate the harmful consequences of these activities by teaching soil conservation techniques and offering promising crops to support a better living for settlers. Meanwhile, extension workers, including Non - Government Organizations (NGOs), have raised awareness among forest dwellers about the importance of soil and nature conservation and are implementing strict control measures. These and other endeavors are helping to slow down the rate of deforestation.

In the dry season, some forest ecosystems are threatened by forest fire that is a cause of forest degradation. Fires are the cheapest way to clear land in upland farming; they stimulate the growth of young leaves and grass for cattle grazing; and make it easier for illegal hunters to hunt wild animals. Small fires to burn ground vegetation are also used as a means to prevent bigger fires that could be detrimental to forest trees. Uncontrolled and unmanaged fires, however, cause significant damage to forests every year. In this regard fire prevention and fire fighting is one of the RFD’s most costly activities.

Reforestation

Reforestation in Thailand started in 1906. Teak was planted via the *taungya* agroforestry system. Small areas were planted annually until 1960. The reforestation program gradually expanded after 1961. The cumulative area planted reached 13,026.47 km^2. A national reforestation campaign was implemented during 1994-1996 with a target area of about 800,000 hectares. The campaign embraced planting of forest trees (i) along roadsides, (ii) around school premises, governmental offices and religious places, (iii) in areas such as parks, recreation areas, dams and reservoirs, riversides, etc. and (iv) in existing degraded forest. The government's farm forestry program (1994 to 2001) was a response to the deteriorated wood supply situation with the target area of 1.28 m ha. The program subsidized the private sector and farmers in tree planting costs: 80,126 farmers joined the program but the planted area only covered 169,400 ha. (1,694 km^2) The program is still ongoing. The total extent of planted forests in 2000 was estimated at 2.81 million ha (28,010 km^2) and there were another 2 million ha (20,000 km^2) of rubber plantations (RFD, 2010). Further more, tree planting in commemorate with 84 years old His Majesty the King have been promoted all over forest ecosystem covering the area of more than 3.5 million Rai (560,000 hectares).

Businesses also support reforestation through a program of Corporate Social Responsibility (CSR). In addition, citizens, communities, school children, Buddhist monks, educational institutes and villagers are joining efforts to plant trees on degraded forestlands on special or national memorial days every year. These activities are over and above the assistance that the RFD provides through Royal Initiative Projects. Furthermore, RFD nurseries in provinces and regions throughout the country distribute millions of seedlings to people and rural communities under the community forest program. In 2007, seedling distribution resulted in the planting of more than 272,000 ha (2,720 km^2) . These trees not only make the areas green but are also future additional sources of timber and non-wood forest products.

Protected areas

According to the National Forest Reserve Act (1964), 9,394,151 ha (93,941.51 km^2) or about 59% of forestlands are declared national reserved forests to protect them from clearing, degradation and occupation as well as to conserve them for amenity, recreation, education, and genetic resources. After the RFD was restructured in 2002, responsibility for protected areas was transferred to the DNP.

By 2010, 123 national parks, 113 forest parks, 58 wildlife sanctuaries, 53 non-hunting areas, 16 botanical gardens and 56 arboreta were spread across the country (DNP, 2010a). They are all protected and strictly controlled by laws such as the 1962 National Parks Act and the 1992 Wild Animal Reservation and Protection Act.

Mangrove forest

Due to exploitation, Thailand's mangrove forest was reduced from nearly 320,000 ha (3,200 km^2) in 1975 to less than 200,000 ha (2,000 km^2) in 1987. In 1996, the Government decided to revoke all mangrove forest concessions and to rehabilitate the degraded forest lands. In 2000, mangrove forests of the country covered 250,000 ha (2,500 km^2) and increased to 275,000 ha (2,750 km^2) in 2004. The importance of mangrove forests has never been more recognized than during the tsunami tragedy in 2004. Areas sheltered by mangrove forests were saved from the devastating effects of the tsunami, while those without such shields were completely destroyed (ONEP, 2011).

Policy framework for forest management and conservation

Communities located within and near forests have been motivated to participate in the sustainable management of natural resources through well-designed conservation policies and legal frameworks, especially those pertaining to forests, which have been amended to address rapid social change and emerging environmental issues. However, some policies, laws, and institutions have not yet been adjusted to adequately respond to the needs of many stakeholders who have been invited to become involved in forest management. Programs often act as barriers to effective participation, especially in community forestry. Weak managerial and technical capacity in both government and communities are also key constraints which make the sector vulnerable to illicit activities such as illegal logging and encroachment. Stronger policies, legal frameworks and institutional structures to deal with the problems associated with natural resources management are therefore critical to achieving long-term sustainable development.

The National Constitution

The National Constitution contains a number of innovative provisions with respect to environmental conservation and sustainable use of natural resources. Participation at all levels of society is well appreciated and recognized within this Constitution. Major policies related to natural resources management, including forests are described below.

1. Communal rights in the conservation and use of natural resources (Article 56)

The Community Forest Bill, still awaiting decree, will give communities the right to design their own rules for the management, use and conservation of the forest in their regions.

2. The right to access information (Article 59)

Although, at first glance, the provision seems remotely related to forest conservation, this article provides a basis for transparency in public management, including the allocation of budgets and the performance of government agencies.

3. The duty of the state to promote and encourage public participation in the conservation and use of natural resources (Article 79)

The state shall promote and encourage public participation in the preservation, maintenance and balanced utilization of natural resources and biological diversity as well as in the promotion, maintenance and protection of environmental quality, in accordance with the principles of sustainable development.

4. The power and duty of local authorities in the management, maintenance and utilization of natural resources (Article 290)

The Constitution clearly assigns responsibility for the protection and maintenance of natural resources and the environment to local authorities.

National forest policies

According to the ONEP (2011), the first 5 year National Economic, Social and Development Plan (NESDP) which was implemented during 1962-1966 set the first explicit goal for forest management and conservation and stipulated maintaining a target of 50% forest cover. At that time, an estimated 53% of the country was under forest cover. Between 1964 and 1992, consistent with the 1964 National Forest Reserve Act, the RFD issued more than one thousand ministerial regulations, declaring almost half of the country to national forest reserves which the government controlled for production and extraction. The national target for forest cover was reduced to 40% in the 5th NESDP (1982-1988) to reflect economic and social conditions. This move led to the first comprehensive National Forest Policy (1985) which further specified that the 40% cover be broken down into 15% conservation forest and 25% economic forest. However, the 8th Plan (1997-2011) turned the development vision of the country to focus on the holistic development approach in order to achieve a balanced development among economic, social, and environmental sectors. This plan was widely recognized as a new paradigm for sustainable development with its extensive involvement of public participation.

The 9th Plan (2002-2006) adopted His Majesty the King's sufficient economic philosophy to guide national development. In this regard, public awareness of natural resources through formal education and information campaigns was developed. The 10th Plan (2007-2011) has maintained the 40% target of forest cover in order to protect natural resource base and keep ecological balance as well as to maximize social benefits and environmental protection. Up to the present, the upcoming 11th plan promises to maintain the environment in good condition and adopt environment-friendly production systems to achieve sustainability.

In addition, a year after a devastating flood in the south of Thailand in 1988 believed to be caused by an increase in deforestation, government imposed a logging ban in natural forests and reversed the ratio of conservation to economic forests to 25% and 15% respectively, figures which remain current.

The Environmental Quality Management Plan

In accordance with the National Environmental Quality Enhancement Act of 1992, Thailand completed its first Environmental Quality Management Plan in 1997 which covered the period between 1999 and 2006. It outlines two strategies for resolving natural resources and environmental issues: institutional reforms for the management of community forests, water resources, biodiversity and the protection of first class watersheds; and public participation as an instrument that will "*instill in people the sense of ownership in natural resources and environment and maintain them*".

Forest land use policy

In 1989, 23,600,000 ha (236,000 km^2) (45.9% of the total area) were gazetted as National Forest Reserves and classified into 3 zones as follows:

1. The C-Zone, *Conservation Forest* consists of areas formerly designated as protected forests and natural forests where human activities are minimal. However, some areas are still used for agriculture and shifting cultivation. Different forest management activities are also taking place in this zone, including the establishment of protected areas - for example, class 1 watershed areas, national parks, wildlife sanctuaries, forest parks, non-hunting areas, biosphere reserves, botanical gardens, and arboreta. By law, people are not allowed to inhabit, cultivate or utilize these gazetted areas. Since a significant number of people occupied this territory prior to the changes, their evacuation is widely controversial at both local and national levels. As a compromise, the government introduced community forestry in an attempt to motivate those living in and near such areas to become involved in resource management. So far, however, the issue remains unresolved and the Community Forest Bill is still pending.

2. The E-Zone, Economic Forest has been designated for commercial plantations and reserved area for landless farmers. The forest is absent, scarce or in poor condition, with cattle grazing in the open fields. Various stakeholders are looking to this zone to expand production forests, establish community forests, or use it for agriculture or agro forestry.

3. The A-Zone, Agricultural Uses is designated as suitable for agriculture and for allocation to landless farmers by the Agricultural Land Reform Office (Rasmussen *et al*., 2002).

Legal framework for forest management and conservation

Thailand, which once exported timber, is now a net importer and has high expectations for the role forests will play in nature conservation. Since 1989, all natural forest (25% of total area) is protected by law from commercial exploitation. Timber and pulp production are meant to be sourced from plantations of mainly teak and fast-growing tree species, although this strategy is not fully developed. The relatively small area of teak plantations which the parastatal Forest Industry Organization (FIO) established 25 years ago is just entering the productive phase. Private sector investment in plantations is rather negligible and only recently a priority in national reforestation.

Apart from altering the country's timber trade balance, the focus on forest conservation is causing tension between authorities and Thai citizens, especially the more than 1 million households that, by law, are illegally inhabiting national parks, wildlife sanctuaries and national forest reserve lands. Balancing the protection of forests with their social, cultural and economic functions is a challenge that Thailand is still in the early stages of addressing.

Rasmussen *et al*. (2002) describes that the major legislation for the conservation of natural resources and the management of forests is listed below.

1. The Act B.E. 2484 (1941) Forest Act

The Forest Act (1941) is among the country's early pieces of legislation on forest management, the purpose of which was to control the harvesting of forest products. Conservation aspects were not included. The function and activities of the RFD, which was founded in 1896, were mainly related to extraction. The original Act reflected the fact that Thailand had abundant and healthy forests but, beginning in 1961, a succession of NESDPs took into account the substantial decline that was occurring and the need to implement conservation measures.

2. The Act B.E. 2535 (1992) Wild Animal Reservation and Protection Act

The DNP administers this Act which focuses on wildlife conservation, the establishment of special territories and the possession and trade of wildlife and their carcasses, for example.

3. The Act B.E. 2504 (1961) National Parks Act

This Act is also the responsibility of the DNP. It provides for the determination, protection and maintenance of national parks and the establishment of a national parks committee.

4. The Act B.E. 2507 (1964) National Forest Reserve Act

The Act provides for the determination of national reserve forests and assigns responsibility for their control and maintenance to RFD.

5. The Act B.E. 2535 (1992) Reforestation Act

This Act was promulgated to support and encourage private sector investment in plantations, as part of RFD's goal to expand planted area.

6. The Act B.E. 2537 (1994) Tambol (subdistrict) Council and Tambol (subdistrict) Administration Organization (TAO) Act

This legislation is an attempt to strengthen the role of local government in natural resources use, planning and decision making.

7. The Act B.E. 2541 (1998) Decentralization Act

The Act contains guidelines for the election of community representatives to the Tambol Council. Natural resource management is addressed within this Act as one of the major duties conducted by the TAO.

Institutional framework for forest management

Thanks to both a strong environmental movement and firm government commitment, King Rama V founded the RFD in September 1896 to oversee teak concessions which were mainly awarded to western businesses. In an attempt to promote a more holistic approach to forest management, in 2002 the government restructured the RFD into 3 departments, all of which employ experienced forestry specialists: the RFD, the DNP and the DMCR. Some duties related to forests and forestlands have also been assigned to the Office of the Permanent Secretary.

However, with regard to the formulation of policy and the functions of planning and management, authorities have overlapping responsibilities, for example, for the NESDP and the Environmental Plan. While MNRE's three departments noted above are tasked with the daily administration and control of forest resources and biodiversity over more than half the country, the ONEP also has a mandate to plan nature conservation and biodiversity protection. Hence, problems arise when policies are translated into laws which line ministries then administer. Implementation is further hampered because matters pertaining to the health of the environment do not take precedence over many regulations governing land use which fall under different ministries.

In practice, MNRE coordinates inter-ministerial policies through the National Environment Board which the Prime Minister chairs. Conflicts over land uses due to overlapping mandates emerge frequently, for example, mining, road construction, and infrastructure development in class 1 watersheds. Disputes must often be settled by cabinet resolution. Cooperation among authorities is needed while overlapping mandates and policies among the responsible agencies should be revised through a national steering committee or through departmental committees, sub-committees and task forces.

At the local level, local authorities in Thailand consist of provincial administrative organizations, district organizations, and tambol organizations or TAOs (1 tambol = 10-15 villages). By the end of 1999, around 6,800 TAOs were established throughout the country, effectively passing authority to the grass-roots. The TAO Act of 1994 and the 1998 Decentralization Act clearly state the mandate and duty of TAOs in the protection and maintenance of natural resources and the environment within their jurisdiction. However, TAOs have exercised little power in these areas to date because most are still concentrating on infrastructure development. The role of other local authorities in the management of natural resources and the environment is not clearly specified in law.

Forest research

Forest research in Thailand started ten years before the RFD was founded in order to develop knowledge on the extent of teak resources. For the early decades, research emphasized the management of natural forest. Four regional silvicultural research stations were established in 1952, and others were added subsequently. The Teak Improvement Center (TIC) in Lampang and the Pine Improvement Center in Chiang Mai were established with Danish support. Four lac research stations were also established to conduct research on *Laccifer lacca* Kerr. Collaborative research projects were carried out with the support of some developed countries. However, after the government restructured the MNRE many research projects have been conducted on a variety of topics under each responsible organization.

Challenge of future forest management

Participatory approaches to forest management are gaining momentum in Thailand and are seen as an effective way to address and resolve issues. However, decentralization and public involvement in policy, planning, and management of natural resources are still rather limited, even though local administrative organizations have been empowered to some extent in recent years and their input is being sought in the development of policies and legislation. Cooperation among authorities and stakeholders is crucial to ensure sustainable forest management in the long run.

Chapter 1

The Current State of Forest Genetic Resources

Diversity within and between forest tree species

In Thailand, there are ten main ecosystem types. Table 1 shows dominant tree flora species and available information of area in each ecosystem type. Some dominant forest tree species are characterized by seed sources and provenance zones in different regions of Thailand.

Understanding the current status of genetic resources across the country is imperative before efficient forest gene conservation programs can be designed. In Thailand, a number of economically and ecologically important forest tree and plant species are under threat due to human pressures. The status of genetic resources of forest tree and plant species can be explored by investigating the extent of genetic variation and the mating system of each species. The extent and distribution of genetic variation within species are of fundamental importance to their evolutionary potential and chances of survival under unpredictable environmental conditions. Therefore, assessment of genetic variation is of key importance for developing effective gene conservation plans and strategies.

The status of genetic diversity of some economically and ecologically important forest tree and plant species in Thailand has been evaluated using molecular markers such as microsatellites simple sequence repeats (SSR), Random Amplified Polymorphic DNA (RAPD), Amplified Fragment Length Polymorphisms (AFLPs), as well as isoenzymes (Table 2).

The results showed that the genetic diversity and mating system varied among species. For instance, *Pinus merkusii* Jungh & de Vriese had low genetic diversity (H_e=0.058) and a relatively low outcrossing rate (tm=0.017-0.843) while teak had high genetic diversity (H_e=0.310) and a high outcrossing rate (tm=0.872-0.995). In Dipterocarps, *Dipterocarpus alatus* Roxb. ex G.Don had moderate genetic diversity (H_e=0.0924) (Changtragoon, 2008). *Shorea obtusa* Wall. ex Blume had high level of genetic diversity (H_e = 0.664). Genetic differentiations between populations, although significant, were low with approximately 3 % of genetic variation partitioned among populations (Senakun *et al*., 2011). In mangrove forests, *Rhizophora apiculata* Blume had also unexpectedly high genetic diversity (H_e=0.316) and a highly variable mating system among populations and families (tm=0.241-0.978), while *R. mucronata* Poir. contained high genetic diversity as well (H_e=0.385). Surprisingly, high genetic diversity was found in wild bamboo (*Bambusa bambos* (L.)) and lady slipper orchids (*Paphiopediium exul* (Ridl.) Rolfe) with the values of expected heterozygosity (H_e) 0.369 and 0.301, respectively. However, the genetic differentiation among populations (F_{st} and Theta P) of those species ranged from 0.0821 to 0.250. Based on the investigated genetic diversity parameters among species, plans are to propose different strategies for *in situ* and *ex situ* conservation for the genetic resources of these forest trees and wild plants in Thailand (Changtragoon, 2008).

To provide further determination of genetic diversity of other medicinal and endangered forest tree species, numbers of microsatellite (SSR) markers were developed in neem

(*Azadiarchta spp.*), *Phyllanthus emblica* L. and siamese rosewood (*Dalbergia cochinchinensis* Pierre).

The genetic differentiation between populations in adaptive traits (survival, health and vigor) is difficult to assess, because it normally requires long-term field trials. However, in the case of teak, a series of trials have been established and evaluated (Kaosa-ard, 1996, 2000). These studies revealed much genetic differentiation between populations within Thailand and also that Thailand represents a unique gene pool of this very important species (Kjær *et al*., 1996; Graudal *et al*., 1999).

Forest Genetics and Biotechnology Division, Forest and Plant Conservation Research Office of the DNP developed a database system to compile and update genetic diversity research in Thailand. The objective of this database is to provide information about the status of genetic diversity of economically and ecologically important forest tree and plant species. Based on the information provided in the database, a conservation program and management of the investigated species can be designed for *in situ, ex situ* and reforestation (Changtragoon and Finkeldey, 1995a, 1995b; Changtragoon, 1997, 2001a, 2001b, 2003a, 2005, 2007, 2008; Graudal *et al*., 1999).

However, capacity-building to enhance assessments and monitoring of inter-specific and intra-specific genetic variations are still needed. DNA fingerprinting to identify the origin of populations and countries of highly economic and endanger species is required, since the populations are under threat due to habitat loss caused by illegal logging and human pressure for agricultural land.

Know-how on phylogeography using DNA fingerprinting and stable isotopes are also needed to identify the origin of wood products among Association of Southeast Asian Nations (ASEAN) regions, so that we can prevent and rectify the illegal logging across borders of the ASEAN region. Work on use of SSR markers to test the origin of teak timber is in progress in Thailand (Changtragoon, pers. com).

The main value of forest genetic resources

The main forest trees species that are actively managed for production purposes by the private sector are both native to Thailand e.g., teak for furniture and construction and agarwood *Aquilaria crassna* Pierre ex Lecomte, *A. rugosa* K.Le-Cong & Kessler and *A. malaccensis* Lam. for incensed wood and medicinal uses and exotic , e.g., *Eucalyptus* species, for the paper pulp and fiber board industries. There are no specific forest tree species managed solely for ecosystem service, but the forest ecosystem also serves as a valuable source of fresh air, water, ecotourism and food. However, Pooma (2005, 2008); Santisuk (2004) reported that 340 forest tree species are threatened (listed in Annex I) and besides the loss of options for future use and biodiversity values per se, degradation of the genetic pool may jeopardize ecosystem functioning in unpredictable ways due to complex interaction among species.

Table 1 Major ecosystem types and flora composition in Thailand

Major ecosystem Types	**Area (covered by ecosystem type)**		**Dominant species for each type**	
	1 000 ha	**km^2**	**Trees**	**Other species if applicable**
1. Moist Evergreen Forest	1,544.89	15,448.85	*Dipterocarpus* spp. *Hopea* spp. *Shorea* spp. *Syzygium* spp. *Vatica* spp.	Bamboos (*Dendrocalamus*, *Bambusa*, *Gigemtochloa* etc.) Palms (*Areca*, *Pinanga*, *Livistona* etc.) Rattans (*Plectocomiaopsis*, *Calamus*, *Korthalsia*, *Plectocomia*, *Daemonorops*)
2. Dry Evergreen Forest	2,290.32	22,903.16	*Dipterocarpus* spp. *Hopea* spp. *Afzelia xylocarpa* Taub. *Hydnocapus* spp. *Vatica odorata* (Griff.) Symington *Vatica cinerea* King	Bamboos (*Bambusa* and *Gigamtothloa*) rattans (*Calamus* and *Daemorops*)
3. Hill Evergreen Forest	1,432.70	14,327.04	*Lithocarpus* spp. *Castanopsis* spp. *Quercus* spp. *Cinnamomum* spp. *Magnolia* spp.	*Cinnamonum* spp. *Schima wallichii* (DC.) Korth. *Manglietia garrettii* Craib *Magnolia* spp. *Calophyllum polyanthum* Wall. ex Choisy
4. Tropical Pine Forest	46.21	462.08	*Pinus merkusii* Jungh & de Vriese *P. kesiya* Royle ex Gordon *Quercus kerrii* Craib *Q. brandisiana* Kurz *Castanopsis indica* (Roxb.) A.DC. *Lithocarpus fenestratus* (Roxb.) Rehder	*Adinandra laotica* Gagnep. *Embelia subcoriacea* (C.B.Clarke) Mez *Maesa Montana* A.DC. *Phoenix humilis* Royle *Cycas pectinata* Griff. *Vaccinium sprengelii* (G.Don) Sleumer
5. Peat Swamp Forest	56.08	560.79	*Calophyllum inophylloide* King *Baccaurea bracteata* Müll. Arg. *Blumeodendron kurzii* (Hook.f.) Sm. *Stemonurus malaccensis* (Mast.) Sleumer	*Oncosperma tigillarium* (Jack) Ridl. *Livistona saribus* (Lour.) Merr. ex Chev. *Licuala spinosa* Thunb. *Ardisia lanceolata* Roxb. *Embelia ribes* Burm.f. *Eleiodoxa conferta* (Griff.) Burret *Korthalsia lacinosa* (Griff.) Mart.

Table 1 (Cont.)

Major ecosystem Types	Area (covered by ecosystem type)		Dominant species for each type	
	1 000 ha	km^2	Trees	Other species if applicable
6. Mangrove Forest	245.25	2,452.55	*Rhizophora* spp. *Xylocarpus* spp. *Bruguiera* spp. *Sonneratia* spp. *Avicennia* spp.	*Acanthus ebracteatus* Vahl *Nypa fruticans* Wurmb. *Suaeda maritima* (L.) Dumort. *Acrostichum aureum* L. *Derris trifoliata* Lour. *Finlaysonia maritima* Backer ex K.Heyne *Aegiceras corniculatum* (L.) Blanco
7. Beach Forest	12.50	124.96	*Casuarina equisetifolia* J.R..&. Frost. *Calophyllun inophyllum* L. *Terminalia catappa* L.	*Vitex trifolia* L. *Ipomoea pes-caprae* (L.) R.Br. *Launaea sarmentosa* (willd.) Kuntze *Spinifex littoreus* Merr. *Canavalus* spp.
8. Mixed Deciduous Forest	8,744.47	87,444.74	*Tectona grandis* L.f. *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen *Pterocarpus macrocarpus* Kurz *Afzelia xylocarpa* (Kurz) Craib *Dalbergia oliveri* Gamble *Dalbergia cana* Graham ex Kurz	*Dendrocalamus membranaceus* Munro *D. strictus* (Roxb.) Nees *D. hamiltonii* Nees & Arn. ex Munro *Bambusa nutans* Wall. ex Munro *B. tulda* Roxb. *Gigantochloa albociliata* (Munro) Munro *Thyrsostachys siamensis* Gamble
9. Dry Dipterocarp Forest	1,856.95	18,569.52	*Shorea obtusa* Wall. ex Blume *S. siamensis* Miq. *Dipterocarpus tuberculatus* Roxb. *D. intricatus* Dyer *Dalbergia oliveri* Gamble *Lagertroemia cochincinesis* Pierre *Terminalia calamansanai* (Blanco) Rolfe	*Cycas siamensis* Miq. *Vietnamosasa pusilla* (Chevalier & A.Camus) Nguyen *Vietnamosasa ciliata* (A.Camus) Nguyen
10. Bamboo Forest	150.35	1,503.50	-	-

Source: DNP (2008a)

Table 2 Comparison of genetic diversity (H_e; Expected heterozygosity*) and genetic differentiation (F_{st}**) among populations of forest trees and other plant species in Thailand

Species	**Type of molecular markers**		**Genetic diversity (He: Expected heterozygosity)**	**Genetic differentiation among populations (F_{st})**	**References**
	Isoenzyme gene markers	**DNA markers**			
Bambusa bambos (L.) Voss		SSR (microsatellite)	0.369	0.243	Laphom and Changtragoon, 2005
Shorea obtusa Wall. ex Blume		SSR (microsatellite)	0.664	0.030	Senakun *et al*., 2011
Quercus semiserrata Roxb.		SSR (microsatellite)	0.68 (nSSR) 0.16 (cpSSR)	0.12 (nSSR) 0.83 (cpSSR)	Pakkad *et al*., 2008
Paphiopedilum exul (Ridl.) Rolfe		AFLP	0.301	0.082	Wanichkul and Changtragoon, 2005
Pinus merkusii Jungh. & de Vriese	√		0.058	0.104	Changtragoon and Finkeldey, 1995a
Tectona grandis L.f.	√	RAPD	0.310	0.217	Changtragoon, 2001a; Changtragoon and Szmidt, 1999; Changtragoon and Szmidt, 2000
Rhizophora apiculata Blume	√	AFLP	0.316	0.250	Changtragoon, 2007
Rhizophora mucronata Poir.		AFLP	0.385	0.212	Changtragoon, 2007
Dipterocarpus alatus Roxb. ex G.Don	√		0.0924	0.182***	Changtragoon and Boontawee, 1999
				0.128	Changtragoon, 2001b

Remarks

* H_e (Expected heterozygosity) is defined as the estimated fraction of all individuals that would be heterozygous for any randomly chosen locus.

** F_{st} is the effect of subpopulations compared to the total populations.

*** Study both primary forests and planted forests.

Some species are identified by using International Union for Conservation of Nature (IUCN) Red list Categories as critically endangered (CR), endangered (EN), vulnerable (VU) and data deficient (DD). For instance, due to the high demand across the border, siamese rosewood in the north-eastern region of Thailand was reported by the DNP, the RFD and a number of local newspapers to be the subject of 454 cases of illegal logging in protected areas. Two hundred twenty nine suspects were arrested during October 2010 to July 2011 (Thai News Agency, 2011). During Jan 2011 to Dec 2011 there were 667 cases of illegal logging, 389 suspects were arrested, and 5,785 logs were put on exhibit. The current surveying found that most of the siamese rosewood was located in the northeastern forests (16,000 ha) and was divided into two forest groups: 1) Phupan forest complex and 2) Phanom Dong Rak forest complex. Most of the illegal logging was in the Phu Jong Na Yoy National Park which harbors the last siamese rosewood forest of the world. It contains trees more than 300 years old with high economic and ecological values.

Iron wood (*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen), makamong (*Afzelia xylocarpa* (Kurz) Craib), makatae (*Sindora siamensis* Teijsm. & Miq.), and pradu (*Pterocarpus macrocarpus* Kurz) are naturally distributed in all regions of Thailand. They are commonly known to be threatened, since they are valued for their uses in railroad sleepers, furniture and construction. However, private companies claimed that the wood used to produce furniture and construction material was imported from neighboring countries, namely Laos, Cambodia and Myanmar. Therefore, tools to identify sources of wood, such as genetic markers, is very important.

There are a number of initiatives focusing on the identification of priority threatened forest species and their potential for use in Thailand. Thailand Conservative Workshop on Forest Genetic Resources Conservation developed an updated priority species listing based on current forest genetic resources status and consultancy Forest Genetic Resources Conservation and Management Project (FORGENMAP) (FORGENMAP, 2000). The members of the workshop agreed that priority species be prioritized into five groups based upon their economic and ecological importance: (A) economic trees; (B) fuel wood; (C) rehabilitation trees; (D) rare/endangered trees; and (E) NWFP species (Table 3).

Some actions on tree improvement and conservation approaches have been taken for the economic trees group. However, for the other groups no action has been taken strategically; therefore the development of an action plan is needed.

Even though an inventory of genetic diversity of the aforementioned species has been carried out, it has not been repeated periodically. Therefore, it is unknown whether genetic diversity has decreased or increased over time. However, forest cover has decreased from 53% in 1961 to 33% in 2009. (DNP, 2010a). This information may indicate that the genetic diversity of most of the forest tree species is decreasing collectively over time. The loss of populations representing unique genecolocal/floristic zones calls for special concern (Suangtho *et al*., 1999).

Table 3 Top five priority species summarized into five groups based on economic and ecological importance

No.	Economic Tree Species	Non-Wood forest product species	Fuel Wood Species	Rare/Endanger Tree Species		Rare/Endangered Tree Species
				Inland Forest	Mangrove/Beach Forest	
1	*Tectona grandis* L.f.	*Bambusa* spp.*	*Eucalyptus* spp.**	*Ficus* spp.**	*Rhizophora* spp.	*Dalbergia cochinchinensis* Pierre
2	*Eucalyptus* spp.**	*Calamus* spp.*	*Leucaena leucocephala* (Lam.) de Wit **	*Peltophorum dasyrachis* (Miq.) Kurz	*Avicennia officinalis* L.	*Cinnamomum porrectum* (Roxb.)Kosterm. [1]
3	*Acacia* spp.**	*Aquilaria* spp.	*Senna siamea* Lam.	*Albizia lebbeck* (L.) Benth.	*Melaleuca leucadendron* (L.) L.	*Mansonia gagei* J.R.Drumm. ex Prain
4	*Dalbergia cochinchinensis* Pierre	*Garcinia* spp.	*Rhizophora* spp.	*Azadirachta indica* A. Juss. [1], **	*Casuarina equisetifolia* J.R. & G.Forst	*Gluta usitata* (Wall.) Ding Hou
5	*Hopea odorata* Roxb.	*Acacia catechu* (L.f. Willd)**	*Combretum quadrangulare* Kurz	*Duabanga grandiflora* (Roxb. ex DC.) Walp.	*Sonneratia caseolaris* (L.) Engl.	*Cinnamomum camphora* (L.) J. Presl [1]

Remarks: * Non-tree species

** Exotic species

[1] *Azadirachta indica* A. Juss., *Cinnamomum porrectum* (Roxb.)Kosterm. and *Cinnamomum camphora* (L.) J. Presl are also valuable for minor forest products.

Source: RFD (2008b)

However, genetic diversity of exotic species namely *Eucalyptus* spp. may increase, since the private sector has produced a number of new clones and may introduce additional clones and seed lots to Thailand for paper plantation industries.

Factors influencing the state of forest genetic diversity

The relative importance of the main forest species being used for timber production has changed significantly over the past ten years. The forces that are driving the changes are policy change, the high cost of timber products, public awareness and cultivation of forest genetic resources. The farmed genetic resources, as well as forest tree plantations and rubber tree plantations run by the private sector, influence markets for substitute timber products with lower costs.

In 1961, nearly 53% of the total land area in Thailand was under forest cover. However due to an increasing emphasis on agricultural and economic development, coupled with increasing population growth, the natural biological resources in the forest have been steadily declining (Office of Environmental Policy and Planning [OEPP], 1997). It is estimated that illegal logging and over-logging of forests, as well as the demand for agricultural land in Thailand, have caused the reduction in forest area to 25.28 % (RFD, 1999). A comparison of existing forest area and periodic changes during 1961-2009 is shown in Table 4 and Figure 3. Between 1961 and 1995, Thailand lost a forest area nearly 3.5 times the area of Switzerland (Changtragoon and Finkeldey, 2000). In the past, the average reduction of forest area was about 23,500 ha (235 km^2) per year (OEPP, 1997). It is in the backdrop of natural decline of forest resources that attempts need to be made to conserve the genetic resources of at least the most important forest tree species and hot-spot forest ecosystem types. As mentioned earlier, from 2000 onwards, forest assessment has being improved by using a higher intensity scale. This technical improvement revealed that more forest cover could be detected as shown in Table 4 and Figure 3.

One of the major threats to forest resources in Thailand is logging. Apart from the loss of uncountable biological diversity, logging operations have resulted in severe soil erosion and flooding, leading to a number of social and economic problems in the country. The logging concessions were withdrawn in 1989, but illegal logging is still active in many region of the country, mainly in reserved forests, which are outside protected areas. Mining industries and infrastructure construction have also caused forest cover loss. Still, Noochdumrong (1998) indicated that the main forces driving land use and land cover change are anthropologic factors such as population growth, income levels, technical change, economic growth, political and economic structure and life style. Among the several measures for trying to maintain the remaining forest resources, the RFD of Thailand has initiated a forest community project and supported the private sector’s investment in forest tree plantations in order to reduce the pressure of the demand for wood and agricultural land (Changtragoon, 2001a).

Table 4 Forest area in Thailand during 1961-2009

Year	Area in		
	Ha (1,000 ha)	Km^2	Percentage
1961	27,362.9	273,629	53.33
1973	22,170.7	221,707	43.21
1976	19,841.7	198,417	38.67
1978	17,522.4	175,224	34.15
1982	15,660.0	156,600	30.52
1985	15,086.6	150,866	29.40
1988	14,380.3	143,803	28.03
1989	14,341.7	143,417	27.95
1991	13,669.8	136,698	26.64
1993	13,355.4	133,554	26.03
1995	13,148.5	131,485	25.62
1998	12,972.2	129,722	25.28
2000	17,011.0	170,110	33.15
2004	16,759.0	167,590	32.66
2005	16,100.1	161,001	31.38
2006	15,865.2	158,652	30.92
2009	17,218.43	172,184.29	33.56

Source: DNP (2010a)

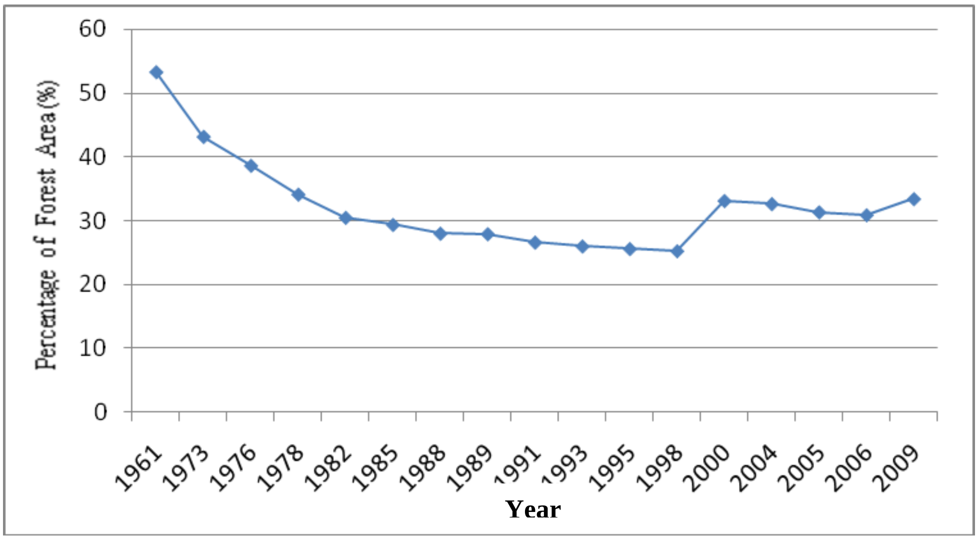


Figure 3 Percentage of Forest Area in Thailand During 1961-2009.

Source: DNP (2010a)

In 1985, national forest policy set a goal of 40% of the geographical area of the nation to be under forest cover, with nearly 25 % comprising conserved forest and 15 % economic forest. Based on remote-sensed imaging during 2009, the DNP reported a forest cover of 33.56%.

Genetic erosion of forest genetic resources has been assessed to some extent in species, ecosystems and degree of genetic diversity. As mentioned earlier, 340 threatened species were reported (Annex I). One mangrove species, lampaen (*Sonneratia alba* J.Sm.) is rarely found in natural mangrove forests. For ecosystem assessment, forest ecosystem hot spots have been surveyed by the ONEP and Tiyanon (pers. com). The levels of genetic diversity and genetic erosion were assessed by Changtragoon (2007) for *Rhizophora mucronata* Poir. in degraded mangrove forests and areas of habitat loss in the resort areas at Chang Island in Trat province (Eastern Thailand).

An information system on threatened species has been published and disseminated through the website of the DNP. Trends in threat and risk disaster analysis for forest genetic resources have been established and undertaken at the forest area and ecosystem level. A survey of peat wetland status was reported in 2009 by the ONEP. A forest fire risk map in Thailand was assessed by Podchong (2010). Ecosystem assessment outside protected areas was undertaken by the ONEP in collaboration with Kasetsart University. Additionally, invasive alien plant species in Kaeng Krachan Forest Complex were surveyed as shown in Annex 2. Their effects upon forest ecosystems were estimated and reported by Jintana *et al*. (2008a, 2008b); Ketanond (2009); ONEP (2009b, 2009c); Wittayawongruji *et al*. (2011).
Thailand also has a policy and protection measure to get rid of alien species (ONEP, 2010).

Based on the modeling of potential changes to forests areas in Thailand under climate change, it suggests that the tropical dry forest ecosystem has the greatest potential to expand into the subtropical moist forest. This analysis further suggests that climate change would have a profound impact on the future distribution and health of forests in Thailand (Boonprakob and Santisirisomboon, 1996). The unusual and frequent heavy rainfall and flooding in Thailand in 2011 may be one of the impacts of climate change. Human pressure for agriculture land, especially rubber plantations, has also affected forest habitat loss. The combination of land use demand and climate change may accelerate forest ecosystem change and habitat loss. Therefore, the country needs priorities to improve forest genetic resources as a disaster response mechanism require a holistic policy and management approach across relevant ministries on human, natural resources and environmental effects. Such policy would need to focus on proper zoning of land uses for forest conservation/protected areas and on utilization of land for agriculture and other sectors. The policy-planning process would require a heightened public awareness and public participation.

Thailand's country priorities to improve monitoring of genetic erosion and vulnerability and to improve the response to observed erosion and vulnerability are as following: 1) long-term genetic diversity assessment in priority and targeted species; 2) long-term satellite and inventory survey on forest cover change and GIS system mapping of endangered and priority species; 3) long-term biodiversity survey by enhancing local community participation; and 4) enhanced public awareness and public participation on values of biodiversity and sustainable use.

Future needs and priorities

The Flora of Thailand Project is a major project to identify species of forest genetic resources by botanists of the RFD and the DNP over a time period of many decades. However, the project lacks an ecologist to investigate the abundance and natural regeneration of identified species. In terms of genetic diversity, the number of forest tree species and wild plants have been investigated using isoenzymes and molecular markers (microsatellites, Random Amplified Polymorphic DNA; RAPD, Amplified Fragment Length Polymorphisms ; AFLPs). However, major constraints are the lack of manpower and adequate budget to run the research projects on the genetic diversity of forest trees.

Priorities for improving the understanding of the state of diversity of forest genetic resources, including associated biodiversity, are to build capacity and manpower in order to estimate genetic diversity and to conduct a species and ecosystem survey on abundance, natural regeneration and habitat loss. Therefore, the capacity-building needs to enhance assessments of the state of diversity of forest genetic resources, including ways to better assess genetic erosion and understanding of its causes, are for research on genetic diversity estimation, a social economic study on the livelihood of local communities and on economic investment related to natural products. The priorities to better understand the roles and values of the diversity of forest genetic resources are economic, social, cultural and ecological values respectively.

In order to establish a strategic direction relevant to improving the understanding of the state of forest genetic diversity and to maintaining this diversity, a national committee on forest genetic resources should be established. Both top-down and bottom-up approaches should be initiated. The country report on forest genetic resources will help by drawing the attention of policy makers to the importance and critical status of forest genetic resources. A national forest genetic resources strategic action plan should be set up through relevant stakeholder consultations. During the process, knowledge on forest genetic resources and public awareness should be transferred to all levels of stakeholders. Therefore, research projects should be identified by all aspects related to conservation, protection and sustainable use of forest genetic resources, especially the estimation of genetic diversity and erosion, in order to use the research findings as criteria and guidance for proper and efficient forest genetic resources management. At the regional level, Thailand is in a good position to serve as a hub for genetic diversity of forest trees in the lower greater Mekong sub-region and beyond, since the DNP has an excellent facility in its DNA and Isoenzyme Laboratory. Therefore, research projects and networking among countries should be established and supported by international organizations and initiatives.

In order to improve understanding of the state of forest resource genetic diversity and conservation and management, a sound strategy for the conservation of genetic resources of a species should begin with the identification of clearly defined conservation objectives. Furthermore, genetic resources must be selected mainly based on the available knowledge of spatial patterns of genetic variation. The choice of conservation method refers to the physical preservation of genetic information, usually by preserving the selected organisms. The final step for a conservation program is the regeneration of the resource (Hattemer, 1995; Finkeldey and Hattemer, 1993). Finkeldey (1998) pointed out that inventories using gene markers are the most important tools for the selection of genetic resources since the center of genetically differentiated populations can be identified by such inventories. However, it is also possible to identify populations containing otherwise rare or even unique alleles in high frequency. The occurrence of localized common alleles also points towards valuable genetic resources (Brown, 1978). Therefore, a combination of different methods is recommended for the identification of forest genetic resources that need to be conserved.

After the genetic variation within and among populations of any species has been investigated, the most variable populations with relatively high outcrossing rates (for outcrossing species) should be chosen as the sources for gene conservation. Since forest trees live longer than annual or crop plants, high levels of genetic variation and outcrossing would guarantee better possibilities for their survival, longevity and resistance to disease and pests for the present and forthcoming generations (Changtragoon and Szmidt, 1997). The combination of marker-aided population genetic analysis and information about adaptive and quantitative traits as well as forest ecosystems would allow comprehensive conservation programs for individual species in each forest type (Changtragoon, 2001a). Recent technological progress has allowed use of novel technologies for such integrated programs (Neale and Kremer, 2011). Therefore, national, regional and global interventions are required.

Chapter 2

The State of *in situ* Genetic Conservation

Introduction

The RFD was founded in 1896 in order to consolidate the Thai government's authority over the extraction of timber from nation's forests. The RFD's original mandate was for plantation establishment, silvicultural research, national parks, wildlife and watershed management, as well as for forest protection. Following the structural reorganization of the RFD in 2002, the RFD became responsible for forests outside protected areas, for which the DNP has responsibility, while the DMCR performs resource management of coastal flora and fauna, including mangrove forests, through conservation and rehabilitation. This made the DNP the responsible department for resources assessment and monitoring within protected areas, while the RFD is responsible for reserved forests outside protected areas. Consequently, both the DNP and RFD with the support of the International Tropical Timber Organization (ITTO), have established a national forest resources monitoring information system that has initiated a national network of 1,285 permanent sample plots for collecting biophysical data over time. In addition, data have been collected from 1,129 additional plots and have been used to update the national forest database. A preliminary mapping of tree volume across the country's forests has been undertaken. A 'panel' approach for plot measurement, whereby one-fifth of the plots are re-measured every year, has been developed. The sampling design used is a single systematic sample of points on a 20 km x 20 km uniform grid, covering all of Thailand's land mass, whether vegetated or not, and including fresh water bodies. Sampling began in 2008, and it is expected that the data from sample plots will provide valuable input for updating information on forest cover, genetic resources and deforestation (DNP, 2008a). In addition to a national forest resources monitoring information system supported by ITTO, a strategic framework for surveys and database establishment on biological diversity and forest genetic resources in protected areas has been adopted as one of the six strategic frameworks in the DNP Four-Year Implementation Plan (2009-2012) (DNP, 2009a). Similarly, a mangrove forest inventory has been carried out extensively by the DMCR. A database and monitoring system were developed in relation to mangrove sustainable use and management. The system has been adopted as one of the six strategic frameworks in the DMCR Strategic Plan for Mangrove Resources Management in Thailand (DMCR, 2009).

The current status of *in situ* gene conservation

Generally *in situ* conservation implies the continuing maintenance of a population within the environment where it originally evolved, and to which it is adapted. *In situ* conservation can have different purposes but, in this report, it refers to genetic conservation and includes protected areas that are established for other conservation purposes and also provide protection for genetic resources.

In situ genetic conservation within protected areas

Since the declaration of the National Parks Act in 1961, Thailand's protected area system was initiated in 1962 with the designation of Khao Yai as the country's first national park. Subsequently, the areas under legal protection have expanded rapidly. Thailand set up a target to have 25% of the country's total land area as protected areas, based on the 7th National Economic and Social Development Board Plan 1992–1996 (NESDB, 1992). At present, the protected area system consists of three protected area categories: (1) protected area declared by Royal Decrees i.e. national parks, wildlife sanctuary, and non-hunting area; (2) protected area declared by Ministerial Declarations i.e. forest park, botanical garden and arboretum; and (3) protected area declared by Cabinet Resolutions i.e. watershed class 1 and 2 and conservation mangrove. In 2010, Thailand has protected areas declared by Royal Decrees (under the DNP's responsibility) accounted for about 20% of the country's total land area (DNP, 2010a). All the 123 national parks and 58 wildlife sanctuaries have been gazetted, covering 11.70 and 7.20% of the total country area (6,032,011 and 3,692,937 ha, respectively). There are also 60 non-hunting areas covering 523,304 ha which are on both private and public lands. In addition, 113 forest parks have been declared by Ministerial Declarations covering an area of 123,900 ha. These protected areas are *in situ* conservation and forest genetic resources are generally well preserved due to strict laws and regulations. The protected area system also includes watershed areas which largely overlap with other protected areas. Table 5 lists the up-to-date categories and protected areas that serve as the country's *in situ* conservation.

In addition to creating the protected area system, Thailand has also declared 1,221 national forest reserves (under the RFD's responsibility) where logging is not allowed. Of the total coverage area of 2,302,864 ha, the northeastern region has the largest coverage of national forest reserves with 1,000,000 ha. About 20% of the country's villages are also located within forest reserves (Tangmitcharoen, 2009). However, forest reserves have obviously less strict laws and regulations compared to those with protected area status (FAO, 2009). In addition, some protected areas in Thailand, where land areas overlap with other categories, e.g. national parks, wildlife sanctuaries and non-hunting areas, are internationally recognized: the World Heritage (Nature), Ramsar Site, Biosphere Reserve and ASEAN Heritage (Table 5).

Table 5 Category and area of protected areas in Thailand

Category	IUCN protected areas category [7]	Number	Total area (100 ha)	Percentage of total country area
By Royal Decrees				
National Park[1]	II	123	60,032.11	11.70
Wildlife Sanctuary[1]	Ia & IIb	58	36,929.37	7.20
Non-Hunting Area[1]	IV	60	5,233.04	1.02
By Ministerial Declarations				
Forest Park[1]	III	113	1,239.00	0.24
Botanical Garden[1,2]	IV	16	45.38	0.01
Arboretum[1,2]	IV	56	43.02	0.01
By Cabinet Resolutions				
Watershed Class 1 & 2[1]	I, II, IV & VI	-	135,553.40	26.40
Conservation Mangrove[3]	VI	-	1,686.98	0.33
By International Recognition				
World Heritage (Nature)[4,5]	II	2	-	-
Ramsar Site[4,6]	IV	10	373.2	0.07
Biosphere Reserve[4]	IV	4	26.1	0.05
ASEAN Heritage[4,5]	II	2	-	-

Note:
1 Data in 2010 by DNP (2010a).
2 Not include as *in situ* gene conservation.
3 Data in 2008 by DMCR (unpublished).
4 Data in 2004 by FAO (2009).
5 The Word Heritage and ASEAN Heritage sites are either wildlife sanctuaries or national parks. Total land area is not shown in overlap with other categories.
6 Eight out of ten Ramsar sites are protected areas.
7 Dudley (2008).

Conservation of target forest species for *in situ* genetic conservation

Thailand has long been involved in forest genetic resource conservation. The process was started with Thai-Danish cooperation in tree improvement, i.e. teak in 1965 and pine and fast growing species improvement in 1969 (Sumantakul, 2004). Subsequently, improvement, conservation and utilization activities have progressed well. Particularly, intensive activities on *in situ* conservation were initiated with lowland source *Pinus merkusii* Jungh. & de Vriese in 1977 (Sumantakul, 2004). Although *P. merkusii* Jungh. & de Vriese is not presently used as a plantation species in Thailand , the species is good for reforestation of poor and degraded soils as well as for community forests. The natural stands, especially in the northeast of Thailand, have been heavily exploited by local communities, primarily as a source of resin and fire sticks. In addition, many good stands are fragmented and declining as a results of the widespread conversion of forest to farmland and frequent fires. The lowland stands that showed the best performance in provenance trials (Hansen *et al.*, 2001) are even threatened with extinction. The aim of *in situ* conservation of *P. merkusii* Jungh. & de Vriese was therefore to conserve genetic variation within the species by selecting a number of populations from different parts of the distribution area. These populations will serve as a source for protection, management and maintenance of genetic resources by providing a basis for future selection and breeding activities as well as for seed sources with a broad genetic base (Danish Forest Seed Centre [DFSC], 2000). Two populations from different parts of the distribution area have been protected and managed since 1977: Nong Khu, Surin province with an area of 100 ha; and Khong Chiam, Ubon Ratchathani province with an area of 960 ha. To meet the conservation criteria, eight genecological zones were later identified. Natural stands in each zone were selected and conservation measures and management options were proposed specifically for each zone based on the available information on its population size, legal protection, social aspects, commercial interest, and management costs (DFSC, 2000). An inventory of genetic diversity for *P. merkusii* Jungh. & de Vriese was also carried out using isozymes as genetic markers (Changtragoon and Finkeldey, 1995b). The three lowland stands of *P. merkusii* Jungh. & de Vriese in northeastern Thailand (zone 8) have been conserved as *in situ* conservation areas, while one lowland stand in the southwest (zone 1) of the country has been surveyed and sought to be conserved accordingly. Furthermore, *ex situ* conservation has been recommended as a complementary conservation strategy for these four stands (Sumantakul, 2004).

Teak is also considered to be a very important species for *in situ* conservation of genetic resources in Thailand as teak forests are under pressure and have already suffered severely from overexploitation and conversion to agricultural land. Teak grows naturally in the northern region of Thailand and is generally limited to Mixed Deciduous Forest in the altitudinal range of 100-900 m above mean sea level. Thailand has been an important supplier of valuable teak timber to the world market for at least 125 years and this timber was harvested by selective logging in the natural forests that may have caused genetic selection towards trees with inferior stem form. Although a logging ban was imposed in 1989, illicit felling has continued. A survey of natural teak forests by Mahidol University and RFD (1995) found that fragments of the original teak forests remain in a total of 15 areas with more than 10 km^2, mainly in seven national parks in the northern part, but only Mae Yom National Park includes a fairly large area with natural teak forests. Density of teak trees in each national park has also been surveyed intensively and approximately 16-80 reproductive trees, diameter at breast height (DBH) >10 cm, were found per ha in the areas. Furthermore, five genecological zones for the remaining natural teak in Thailand have been identified based on the examination of topography, climate and vegetation (Graudal *et al*., 1999). Measures proposed/considered for the *in situ* conservation of the genetic resources of teak have been tentatively identified in 15 locations covering all genecological zones and implementation of the conservation plan comprising a number of activities have been recommended: field survey and selection of the populations; demarcation and protection; monitoring; and management guidelines (Graudal *et al*., 1999). Three locations of teak natural stand were subsequently selected for *in situ* ecosystem conservation as shown in Table 6. In addition, Thailand’s last great stand of teak forest was recently found up to 1,300 m above mean sea level in Pai Watershed Wildlife Sanctuary, Mae Hong Son, and had been later established in 2011 for teak genetic resources conservation through the King’s initiative project (DNP, 2011). Alternatively, large teak plantations developed as seed stands, provenance and clonal test plots as well as seed orchards managed by the teak improvement program over the years have established a broad base for future genetic replenishment. However, the above stands and plots were not executed for the purpose of either *in situ* or *ex situ* conservations (Sumantakul, 2004).

Ecosystem conservation for *in situ* genetic conservation

The rapid depletion of natural forests in Thailand during the past four decades caused tremendous loss of genetic diversity of plants and animals as well as organisms through the reduction of forest areas. Conservation of ecosystems has become vital to the existence of economically important plant and tree species for future use, e.g. various fields of studies, recreation, tree improvement as well as climate change. Therefore, *in situ* conservation of forest genetic resources in terms of "ecosystem conservation" has been initiated in Thailand since 1999 by the RFD aiming at maintaining the natural habitats of economically important species, endangered species as well as rare species and allowing for natural regeneration for the diverseness of their genetic diversity (Sumantakul, 2004). Seven forest types, in the national forest reserves, national parks and wildlife sanctuaries, were selected within the country and a total of 15 locations were chosen for ecosystem conservation programs (Table 6). Demarcation and mapping were made after selection and the number of species was counted from two to four permanent sample plots of 100 x 100 m^2 in size. A line plot system was used for counting in mangrove forests. Other studies such as density, frequency, dominance, relativity were also determined. Because of the restructuring of the RFD governing body in 2002, the ecosystem conservation was later undertaken by the DNP.

National policy relevant to *in situ* genetic conservation

There are several national policies and measures that emphasize conservation and management of forest genetic resources including *in situ* conservation in particular.

The Tenth NESDB Plan 2007-2011 focuses on conservation of natural resources and biodiversity (NESDB, 2007). A strategy for development of biodiversity and conservation of the forest genetic resource base and the ecological balance with a specific target to establish a complete national biodiversity database was prioritized. In addition, Thailand formulated a national policy on the CBD which proposed new and additional incentives to exiting relevant institutions in order to support the conservation and management of biological diversity of the country (ONEP, 2004). Measures for *in situ* conservation of biodiversity are particularly emphasized in two of the seven strategies:

(1) Conservation of species, populations and ecosystems with the objective to improve capacity in the conservation of species, population and genetic diversity in natural habitats; and
(2) Enhance efficiency in management of protected areas to ensure sustainable protection of overall biodiversity at local level with the objectives to ensure that the protected areas capable to conserve rare and endangered species and ecosystems, to increase capacity in protected areas management and to improve the conservation of protected areas.

In addition, several measures from the remaining strategies are supportive of national *in situ* conservation of biological diversity.

Table 6 Ecosystem conservation in Thailand

Forest type	Location	Area (ha)	No. of studied plots	Observed number of species
Moist Evergreen	Khao Luang National Park, Nakhon Si Thammarat	48/64	4	95-115
Moist Evergreen	Hala-Bala Wildlife Sanctuary, Pattani	400	4	100-130
Dry Evergreen with *Hopea odorata*	Vieng Kosai National Park, Phrae	80	4	55-72
Mixed Deciduous with teak	Mae Yom National Park, Phrae	96	4	47-66
Mixed Deciduous with teak	Um Pang Wildlife Sanctuary, Tak	560	4	31-41
Mixed Deciduous with teak	Mae Yuam National Reserve, Mae Hong Son	760	4	38-46
Dry Evergreen	Mae Salid-Pong Daeng Tak	480	4	66-79
Dry Evergreen	Khao Pu Luang National Reserve, Nakhon Ratsima	160	4	48-61
Dry Evergreen	Klang Aow Forest Park, Prachuab Kiri Khan	192	4	38-63
Tropical Pine with *Quercus*	Nam Naoh National Park, Phetchabun	480	3	17-36
Dry Deciduous Dipterocarp	Phupan National Park, Sakon Nakhon	160	2	32-35
Dry Deciduous dipterocarp	Huai Mae Dee, Uthai Thani	104	4	34-52
Dry Deciduous Dipterocarp with pine	Phu Khao Kaew and Dong Pak Chom forests, Loei	480	4	19-26
Peat Swamp	Bang Nara Watershed, Natathiwat	160	2	41-43
Mangrove	Kung Kraben forest, Chantaburi	128	1	8

Major constraints to *in situ* genetic conservation actions

Thailand's forest genetic resources have been subjected to continuing pressure and devastation. The deforestation rate estimated between 2000 and 2005 is at 1.07%, which is higher than the rate of 0.73% that has been so far assumed for the past decades. Shifting cultivation, land settlement, physical infrastructure, conversion to agricultural land and land development for tourism are considered to have caused deforestation and forest degradation during the past decades (DNP, 2008a). Therefore, Thailand initiated the *in situ* conservation of forest genetic resources in 1970s with the support of the Royal Danish Government and obtained substantial know-how in the improvement of economically important tree species during the past four decades (DFSC, 2000; Sumantakul, 2004). In addition, Thailand has adopted several national policies and action plans that emphasized the conservation and management of forest genetic resources. Nevertheless, the government reorganization of the RFD in accordance with the Government Body Restructuring Act 2002 has hindered some action plans and/or operating activities related to conservation of forest genetic resources during the transfer of the duties and responsibilities among the key departments. This was primarily due to a lack of clear understanding of the duties and responsibilities of each department as well as an integration-oriented action plan for the management of forest genetic resources.

National priorities for future *in situ* genetic conservation actions

Thailand has directly and continually engaged in the *in situ* conservation of forest genetic resources since 1970s, particularly targeting some threatened species and some natural habitats of economically important species, endangered species as well as rare species (DFSC, 2000; Sumantakul, 2004). Although the genetic resources of many indigenous species have been conserved as *in situ* ecosystem conservation, silvicultural practices and management are essential to promote the natural regeneration of the existing conservation areas. In addition to *in situ* ecosystem conservation, *P. merkusii* Jungh. & de Vriese has been chosen as a target species for *in situ* genetic conservation (Sumantakul, 2004), but widespread land encroachment to grow para rubber trees recently occurred in these *P. merkusii* Jungh. & de Vriese stands. Action plans to effectively increase local awareness and support of communities for conservation and sustainable management of existing *in situ* conservation areas should be, therefore, established. Furthermore, the forest tree improvement of some economically important species e.g. teak, pines and hardwood species has been developed and future planting programs are planned. Both the public and private sectors, will use a greater diversity of species, both indigenous and exotic. *In situ* conservation of genetic resources for priority species should be expanded in the future by providing planting materials with greater diversity.

National priorities for forest genetic resources conservation and management were set to provide useful information on priority actions for conservation of forest genetic resources of indigenous tree species in Thailand e.g. a study on the status of *in situ* conservation, strategies of forest genetic resources conservation and research needs regarding some of the priority species (FORGENMAP, 2002a). Although limited resources are available for determining priority species for conservation of genetic resources, priorities are as follows: (1) species with socio-economic importance, both the commercial importance and the importance for maintaining ecosystem functions and services; (2) species with higher levels of genetic diversity; and (3) species with populations at risk or under threat from any cause e.g. critically endangered, endangered or vulnerable species. Some indigenous tree species meeting the main criteria as mentioned earlier have been identified accordingly as top priority, very high priority and other priority for future *in situ* conservation action e.g. siamese rosewood, *Afzelia xylocarpa* (Kurz) Craib, *Dipterocarpus alatus* Roxb. ex G.Don, *Hopea odorata* Roxb., *Pterocarpus macrocarpus* Kurz, teak etc. (Table 7) (FORGENMAP, 2002a). It is also important that detailed information of these individual tree species is sufficient for decision making. Research needs that provide more confident information about individual species for conservation can be identified: taxonomy; the importance of species for maintaining ecosystem functions and services; the level of within-species variation; threat or risk of species to extinction; the use of genetic markers in conservation; participatory system on conservation; and biological and demographical characteristics (Sumantakul, 2004).

Table 7 Summary of priority actions for *in situ* conservation and *ex situ* conservation of genetic resources in Thailand (adapted from FORGENMAP, 2002a)

Species	Research needs			Conservation strategy	*In situ* conservation		*Ex situ* conservation	
	Taxonomy	Genetic variation	Distribution		Current situation	Additional sites	Current situation	Additional sites
Top Priority								
Dalbergia cochinchinensis Pierre		2+	3	3*	••		•	1
Afzelia xylocarpa Craib		3	3	3	•••	1(South)	•	1
Dipterocarpus alatus Roxb.ex G. Don		3*	3	3	•••		•	1
Hopea odorata Roxb.		3	3	3	•••		•	1
Pterocarpus macrocarpus Kurz		3+	3	3*	•••		••	1
Tectona grandis L.f.		3+	2	+	•••	1	•	1
Very high priority								
Alstonia scholaris (L.)R.Br.		2	2	2	•••		•	2
Aquilaria crassna Pierre ex Lec.		2	3	2	••			1
Dalbergia oliveri Gemble		2	3	2	••		•	1
Intsia palembanica Miq.		2	2	2	•••			2
Manifera (wild species)	1	2	3	2	•••			2
Millettia kengensis Craib		2	3	2	•	2(North)		2
Pinus merkusii Jungn & de Vriese.		1+	1+	+	•••	2(Northeast)	••	2
Wrightia arborea (Dennst.) Mabb.		2	2	2	•••			2
Xylia xylocarpa var. *kerrii* Craib & Hutch.		2	2	2	•••		••	2
Other priority								
Azadirachta excelsa (Jack) Jacobs		1	1	1	••			3
Chukrasia tabulasia A.Juss	2	1*	1	1*	•••		••	3
Cotylelobium melanoxylon Pierre		1+	1	1	••	2(South)		3
Dipterocarpus tuberculatus Roxb.		1	1	-	•••			3
Durio mansoni Bakh.		1	1	1	••	2(South)		3
Fagraea fragrans Roxb.		1	1	1	••	2(Center,East)		3

Table 7 (Cont.)

Species	Research needs			Conservation strategy	*In situ* conservation		*Ex situ* conservation	
	Taxonomy	Genetic variation	Distribution		Current situation	Additional sites	Current situation	Additional sites
Gmelina arborea Roxb.		1+	1	1	•••		•	3
Holoptelea integrifolia (Roxb.)Planch.		1	1	1	••	2(Northeast, East,West)		3
Hopea ferrea Roxb.		1	1		•••	2(West,Center)		3
Manglietia garretti Craib		1	1	1	••	2(West,Center)		3
Mansonia gagei Drumm.		1	1	1	••			3
Melia azedarach L.		1	1	-	•••			3
Meliantha suavis Pierre		1	1	1	•••			3
Parashorea stellata Kurz		1	1	1	••	2(East)		3
Parkia speciosa Hassk.		1	1	1	•••	2(Center)		3
Pinus kesiya Royle ex Gordon.		1+	1+	1	•••		•	3
Shorea henryana Pierre		1	1	1	•	2(South,East ,West)		3
Shorea roxburghii G.Don.		1	1	1	•••	2(Center, East,West)	•	3
Tetrameles nudiflora R.Br.		1	1	-	•••			3
Toona ciliata M. Roem.	*	1	1	1	•••	2(Center,West)		3

Remarks:

Research needs and conservation strategy:

3 = Top priority: to be undertaken within the next three years; 2 = High priority: to be undertaken within the next five years; 1 = Medium priority: to be undertaken within the next ten year; * = study in progress; and + = study completed.

In situ conservation and *Ex situ* conservation:

••• = very well conserved; •• = well conserved; and • = partly conserved.

Additional sites

NE = north-east; N = north; C = central; E = east; W = west; S= south/peninsula.

Though efforts and resources with several countries have been put into some technical collaboration activities on *in situ* genetic conservation, still some constraints are limiting the progress of most programs. To improve the conservation and management of forest genetic resources, follow-up of existing activities and strengthening of international collaboration networks should be considered.

More importantly, an updating of forest genetic status and an establishment of a complete national biodiversity database in accordance with national policy relevant to *in situ* genetic conservation should be actively implemented. In addition, an integration-oriented action plan including both an operational and a research framework developed by relevant departments, is necessary for the *in situ* conservation and management of genetic resources.

Chapter 3

The State of *ex situ* Genetic Conservation

Introduction

Ex situ gene conservation of forest genetic resources in Thailand is mainly carried out in the form of field conservation, field collections or field genebanks. The *ex situ* approach is often applied to living plant species for experimental purposes and for creating storage of diverse plant species. *Ex situ* gene conservation is conducted applying (i) plantation stands, *e.g.* in the form of genebanks, clone banks, gene conservation plots, botanical gardens and arboreta, and (ii) tree improvement plots, such as, progeny tests, provenance trials, clonal tests and seed orchards.

His Majesty the King of Thailand started *ex situ* conservation since 1961 by creating a demonstration forest within Chitrada Palace. The demonstration forest contains 1,250 trees of *Dipterocarpus alatus* Roxb. ex G.Don and other various plants. This source was mainly for students studying within the Chitralada Palace ground.

Her Royal Highness Princess Maha Chakri Sirindhorn initiated a Royal project to the Lord Chamberlain to conserve plant genetics in 1992. Plant Germplasm Plot was established in 1993 at the Royal Chitralada Projects and plant genetic conservation activities were started. Those activities included exploration, collection, plantation, conservation and utilization of plant genetic materials development of plant varieties, creation of a plant germplasm database center and awareness of plant population genetics, and support of special activities for plant genetic conservation. The botanical garden school has been operated to strengthen the awareness of plant genetic conservation among students from kindergarten until university level. Until October 2011, more than 1,467 (Juthamas, pers. com) in all regions of the country have been registered as participants in this activity. In addition, long-term seed storage also includes plant genetic conservation projects. The Seed Gene Bank for both orthodox seed and recalcitrant seed of plant variety has been established within Chitralada Palace since 1991. In 2011, two more seed gene banks in the central (Nakhonratchasima Province) and in the north (Chiangmai Province) have been developed mainly to secure food, agriculture, and plant improvement purposes (Plant Genetic Conservation Project Under The Royal initiative of Her Royal Highness Princess Maha Chakri Sirindhorn, 2011).

Other agencies and bodies (Botanical Garden Organization, university, state enterprise, forest community, and non-governmental organization) are also involved in *ex situ* genetic conservation through establishment of botanical gardens, arboreta, gene conservation plots.

Approximately 56 species are determined as target species for *ex situ* conservation programs of which 49 are native species. Economic and minor forest products are the major uses of *ex situ* species (Annex 2). The target species were selected based on the report on a national consultancy workshop on strengthening forest genetic resources management in Thailand (RFD, 2008a), consultancy report on forest genetic resources conservation and management program (FORGENMAP, 2002a) and on domestic reports (Boontawee and Saiwa, 1997; Tiyanon *et al*., 2007)

Current Status of *ex situ* genetic conservation in the country

Thailand joined international organizations to establish *ex situ* conservation networks of both indigenous and exotic tree species. Among indigenous species, special attention paid to teak and pine (*P. kesiya* Royle ex Gordon and *P. merkusii* Jungh. & de Vriese), Teak and Pine improvevement programs have been initiated in 1964, and 1968, repectively. Among exotic species, *Pinus caribaea* Morelet, *P. oocarpa* Schiede, and *Eucalyptus camaldulensis* Dehnh. were conserved in plantation stands in the northern (Chiengmai province) and north-eastern (Surin and Ubon Ratchathani Province) regions of the country under a FAO-coordinated *ex situ* forest genetic resources conservation program in 1973 (Sumantakul, 2004). A clone bank was established for some major economically important species such as teak, *Eucalyptus* spp. and *Acacia* spp.

Seventy-two arboreta and botanical gardens were established throughout the country covering an area of 8,840 ha (55,253 rai). There are 56 arboreta and 16 botanical gardens (Table 5 in Chapter 2). There are four literary botanical gardens and four Botanical Gardens located in the northern, northeastern, central, and southern regions of the country.

The objectives of establishment are to collect living plants of both native and non-native species to Thailand for botanical research, as well as to conserve and propagate native plants, particularly the rare, endemic and economically important species. They also serve as a collection center for herbarium specimens, education, and recreation centers for tourists and local people, for pleasure and to raise environmental awareness.

Special attention is mainly focused on tree improvement of economically important tree species such as teak, *Aquilaria* spp., *Chukrasia* spp., *Pinus caribaea* Morelet, as well as on fast-growing native tree species for economic forest plantations, including native species like *Melia azedarach* L., *Casuarina equisetifolia* J.R & G. Forst. Teak was the first species selected for the tree improvement program. The first teak seed orchard in Thailand was established in 1965 at Maegar seed orchard, Phayao Province. 400 superior teak clones were selected in natural Thai teak forests of the Thai breeding program (Kaosa-ard *et al*., 1998), representing a unique gene pool of high conservation value.

Among exotic tree species, *Acacia* spp., *Casuarina junhuhniana* Miq., *Eucalyptus* spp., and *Azadirachta excelsa* (Jack) Jacobs (native to Borneo) are also included for tree improvement programs. In addition, progeny tests cum seed orchard of several species (*Phyllanthus emblica* L., *Pterocarpus macrocarpus* Kurz, siamese rosewood, *P. caribaea* Morelet have been recently established.

Tree improvement plots, for at least 27 species (teak is the main species) have been established and classified as improved seed stands in so-called seed production areas, provenance seed stands and seed orchards (Annex 3) covering an area of 1,662 ha (10,389 rai) throughout the country.

In addition, *ex situ* conservation plots, in the form of genebanks and gene conservation plots, of eight indigenous hardwood species were established under the cooperation of the RFD and Danish International Development Agency (DANIDA) Forest Seed Center in 1989-1993. The stands are located at five sites in central and north-eastern regions. In total, 386 plus trees of eight timber species were selected and well conserved in five provinces on a total area of 356 ha (Annex 4). There were, however, no detailed genecological studies on the natural variation within these stands.

More than 3,670 plus trees have been selected for 70 species of both native and exotic in natural forest and plantation. The major groups of the plus trees are from teak, siamese rosewood, *E.camaldulensis* Dehnh. (Annex 5). More plus trees were selected by other state enterprises (i.e. FIO) and private sectors.

Use and transfer of germplasm in the country

Seed is the major planting material in the country. Unfortunately, the majority of seed sources distributed for general planting programs are from unimproved or unidentified seeds sources. However, the RFD has made an effort to promote the use of better genetic materials to tree farmers; simultaneously with developing higher quality seed sources through several activities, such as conducting tree improvement projects and establishing additional seed orchards.

Annual plan of seed collection has been officially made based on demand of users. Approximately 5,900 kg of seed were collected from seed collection zones, identified seed sources, seed production areas, provenance seed stand, and seed orchard throughout the country. Teak has been successfully developed in terms of seed source development. The species has a high potential to produce up to at least 3 tons of improved seeds per year. In terms of seed distribution, in the year 2010, 4,858 kg of seeds from 58 species have been distributed to domestic users. A total of 19,071 kg of 83 species has been stored at four regional seed centers (north, northeast, central, south) and laboratories of the Silvicultural Research Group at the RFD.

Documentation and characterization used

Development of the sources of germplasm is one of the management practices of forest genetic resources under the RFD. The activities focus on the establishment and development of sources of genetic materials, including the sources for seed production of forest trees. In addition, the RFD develops field plots on which certain trees are selected as plus trees and seed trees. The aim is to produce and promote the use of high-quality genetic material for both sexual (using seeds) and asexual reproduction (cutting or grafting).

The FORGENMAP 1997-2002, was one of the projects playing a vital role in forest genetic resources conservation and management in Thailand. Its main objectives were to develop germplasm seed sources and to conserve forest genetic resources.

With regard to the development of the seed sources, the RFD adopted a system for the classification of seed sources as part of FORGENMAP. The system is based on the pattern of the Organization for Economic Cooperation and Development (OECD, 1974) and that of the DFSC, with some adjustments made to suit forest conditions in Thailand. It classifies seed sources into six classes according to their characteristics. The classes from lowest to the highest stand quality are Seed Collection Zone or Ecozone (SCZ), Identified Stand (IS), Selected Stand (SS), Seed Production Area (SPA), Provenance Seed Stand (PSS) and Seed Orchard (SO) (Tangmitcharoen, 2007). Identified stands, classified as being of low to medium quality, are the most common source registered in the seed documentation system (FORGENMAP, 2002b).

Apart from the classification and improvement of seed sources, the RFD has recently developed seed sources in accordance with a plot rehabilitation scheme under the Work Plan for Developing the Potential of Forest Research (2008-2012). According to this scheme, trial plots of various species which occupy a total area of approximately 3,200 ha will be rehabilitated to good-quality seed sources. Moreover, by using genetic material, these plots will be developed to areas of *ex situ* conservation of various valuable species.

In addition to direct approaches such as selection of plus tree, establishing tree improvement plots *i.e.* progeny test, e*x situ* conservation can be promoted through capacity-building on education and training and strengthening national and international collaborative networks for the management and use of forest genetic resources (Tangmitcharoen, 2009).

The priority for future ex situ genetic conservation actions

Priorities for forest genetic resources conservation and management including *ex situ* conservation were made in 2002, as appeared in Consultancy Report 20 of FORGENMAP (FORGENMAP, 2002a). The report provided useful information on priority forest genetic resources conservation actions for indigenous tree species in Thailand such as status of *ex situ* conservation, strategies of forest genetic resources conservation and research needs for some priority species. Among the list of over 29 species, top priority species are siamese rosewood, *Afzelia xylocarpa* (Kurz) Craib, *Dipterocarpus alatus* Roxb. ex G.Don, *Hopea odorata* Roxb., *Pterocarpus macrocarpus* Kurz,teak (Table 7 in Chapter 2).

In addition to the priority species list in 2002, a list of updated priority species was prepared in 2008 through a national consultancy workshop on strengthening forest genetic resources management in Thailand. Tree species have been grouped into five groups; economic tree species, fuel wood species, rehabilitation species, rare/endangered tree species and minor forest products species. (Table 3 in Chapter 1).

It is likely that siamese rosewood classified as a vulnerable species by the IUCN red list of threatened species (IUCN, 2009) will become the top priority species for the group of rare/ endangered tree species and economic tree species. Other than illegal logging for domestic uses in the past, recently the logging of the species has been tremendously expanded in terms of the areas and amount of wood due to high wood demand especially from China. Therefore, *ex situ* conservation of this species should be considered more seriously for the sake of maintaining genetic diversity and the study of tree improvement in the future.

The capacity-building needs and priorities for *ex situ* genetic conservation actions are research and training. As indicated above, priority research is needed in the field of genetic process and variation, distribution and status of target species. Training on *ex situ* conservation is another action that can play an important role in forest genetic resources management. Unfortunately, there is no regional training course in the conservation and management of forest genetic resources, in particular *ex situ* genetic conservation.

It could be concluded that Thailand directly and continually operates in *ex situ* genetic conservation in the form of field conservation. The tree improvement plots and seed source areas of many economic tree species including teak, pines and some hardwoods have been conserved and developed. At present, at least 70 species have been explored and selected for additional improved genetic materials.

Follow-up of previous work in terms of establishment of *ex situ* conservation plots, research and tree improvement program is necessary to maintain the existing *ex situ* genetic conservation plots and also to proceed for further steps. Simultaneously, promoting uses of better germplasm to tree farmers is also essential and should be considered as priority work to extend the success of the conservation effort and to contribute benefits to the stakeholders.

Finally, a national strategy of *ex situ* genetic conservation is required to develop a clear action plan among the key departments for both short-term and long-term *ex situ* genetic conservation management to achieve the goals of sustainable uses of forest genetic resources for communities and for people.

Chapter 4

Use and Sustainable Management of Forest Genetic Resources

The importance of sustainable management and use

All forests in Thailand are owned by the state whereas all trees established on private lands are private property. Since logging in natural forests is banned, timber production in Thailand has shifted from natural forests to plantations. Reforestation in Thailand also been carried out by the private sector for more than 30 years. Teak, *Pinus* spp., *Casuarina* spp., *Eucalyptu*s spp. and *Acacia* spp. are the main tree species selected for reforestation. Particularly, *E. camaldulensis* Dehnh. and Eucalyptus hybrids, which are exotic fast-growing tree species, were mostly chosen for private sector reforestation. The plantation areas of government organizations and private sectors in 2008 for those tree species were Teak: 836,000 ha, *Pinus*: 689,000 ha, *Casuarina*: 148,000 ha, *Eucalyptus*: 480,000 ha (private sectors only) and *Acacia*: 148,000 ha (RFD, 2009).

The goals of sustainable management and use of forest genetic resources are to improve wood production, to provide other benefits from growing woody plants, to contribute to the rehabilitation of degraded environments and to help meet the national requirements for timber, poles,fuel wood, fodder, food and shelter in Thailand.

The sustainable management of forest genetic resources followed a tree domestication strategy comprised of a continuing process e.g. biogeographical description and local knowledge, representative sampling, assessment and propagation, assembly of base populations, improvement (breeding and propagation), and sustainable use as shown in Figure 4.

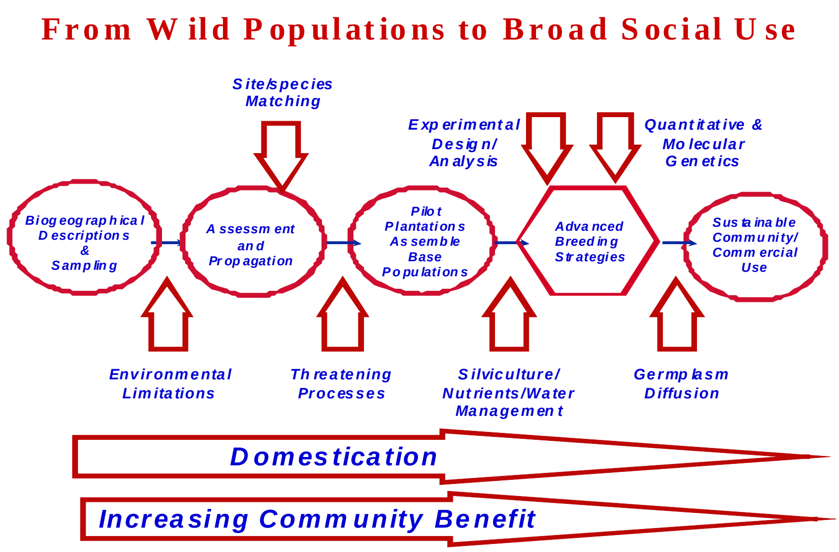


Figure 4 Sustainable management of forest genetic resources from wild populations to broad social use.

Source : Adapted from Midgley and Turnbull (2003)

Utilization of conserved forest genetic resources and major constraints to their use.

In 2010, the RFD supplied 970 kg seed of 58 species from *in situ* and *ex situ* gene conservation to farmers and government plantation projects (forest rehabilitation, watershed management, community forest, greenhouse gases absorption etc.). Determination of priority species for forest genetic resources conservation requires careful consideration. Only limited resources are available for forest genetic resource conservation in Thailand. Table 8 lists species for tree improvement programs and their utilization

Table 8 Forest improvement programs

Species		Improvement program objective				
Botanical name	**Native (N) or Exotic (E)**	**Timber**	**Pulpwood**	**Energy**	**MP***	**NWFP****
Tectona grandis L.f.	N	✓				
Dalbergia cochinchinensis Pierre	N	✓				
Pterocarpus macrocarpus Kurz	N	✓				
Phyllanthus emblica L.	N				✓	✓
Gluta usitata (Wall.)Ding Hou	N					✓
Aquilaria spp.	N					✓
Pinus kesiya Royle ex gordon	N	✓	✓			
Pinus merkusii Jungh.& de Vriese	N	✓	✓			
Eucalyptus camaldulensis Dehnh	E	✓	✓	✓		✓
Eucalyptus urophylla S.T. Blake	E	✓	✓	✓		
Eucalyptus pellita F Muell.	E	✓	✓	✓		
Acacia auriculiformis A.Cunn. ex Benth	E	✓		✓	✓	
Acacia mangium Willd.	E	✓		✓	✓	
Acacia crassicarpa A.Cunn. ex Benth	E	✓		✓	✓	
Acacia aulacocarpa A.Cunn. ex Benth	E	✓		✓	✓	
Casuarina junghuhniana Miq.	E	✓		✓	✓	
Pinus caribea Morelet	E	✓	✓			
Pinus oocarpa Schiede	E	✓	✓			

* MP : Multipurpose tree improvement program
**NWFP : Non-wood forest product

The state of forest genetic improvement and breeding programs

a. Teak (*Tectona grandis* L.f.)

Genetic improvement activities for teak in Thailand were initiated in the early 1960s (Boonkird, 1956) to improve genetic quality and propagation techniques for plantation establishment. These activities included provenance trials; plus tree selection; establishment of clonal seed orchards, seed production areas, clone bank and clonal trials; and development of vegetative propagation techniques and supporting research.

Approximately 500 plus trees have been selected from six northern provinces (Lampang, Phrae, Mae Hong Son, Tak, Chiang Mai and Sukhothai) and one southern province (Yala) in Thailand. This collection includes trees identified and selected based on a detailed survey in the natural teak forests. Collections from the 60'tiers and forward (Kaosa-ard *et al.*, 1998) represent a unique gene pool of very high quality teak trees that may later have been logged before the logging ban. Clone banks of these plus trees have been established in five locations to minimize risk of insect pests and natural disaster. Clonal trials have been established since 2000 in each region of Thailand with 16 – 20 selected clones having been found to be suitable for each region. The evaluated clones will be propagated and distributed to farmers.

The total area of teak seed orchards established in six provinces is about 1,600 ha. The capacity of seed production is sufficient to produce about 7-8 million seedlings per year, but the production capacity may be increased based on intensified management and improved nursery practices (Kaosa-ard *et al.*, 1998).

Breeding orchards for control pollination and propagation techniques of new genetic materials are being carried out in Ngao Silviculture Research Station (former name "Teak Improvement Center - TIC").

Half-sib and full-sib progeny and clone-progeny trials from open-pollinated clonal seed orchards and controlled pollination have been established in four silviculture research stations in Pruchuap Kiri Khun, Kanchanaburi, Phitsanulok and Khon Kaen. At present, the teak breeding plan is intended to improve superior teak, growth rate at diameter at breast height more than 2 cm/year or mean annual increment of 0.4 m^3/ha/year by controlled pollination of tested plus-trees and seedlings propagated by tissue culture and cuttings for progeny test and economic teak plantation.

Future plans for teak improvement activities are to establish second generation breeding and to distribute genetically improved material for plantation establishment.

b. *Eucalypts* spp.

A systematic breeding program for *E. camaldulensis* Dehnh in Thailand commenced in 1991 with support from Australian Centre for International Agricultural Research (ACIAR) and Commonwealth Scientific and Industrial Research Organization (CSIRO) Forestry and Forest Products (Raymond, 1991). The program was implemented by the RFD in collaboration with other state forest enterprises. An extensive range of 300 individual parents from Queensland, Northern Territory and Western Australia was used to establish large progeny trials cum seedling seed orchards. The results of these progeny trials at two years of age indicated great variation in growth performance among regions and provenances within regions, despite the existence of considerable variation between families within provenance (Pinyopusarerk *et al.*, 1996). Provenances from Queensland were superior in growth rate to those from the Northern Territory and from Western Australia. The results have provided important baseline data for selection of appropriate provenances and families for the second generation breeding program. A second-generation progeny trial was recently established with seed from selected parents from the first-generation seedling seed orchards.

Another improvement program for eucalypt species is *E. urophylla* S.T.Blake With assistance from the Australian Tree Seed Center, the RFD established a seedling seed orchard comprising 121 families in 1989. Regular seed collection from this orchard has been carried out over the last five years. Seed has been supplied to private companies. A second-generation seedling seed orchard was planted in 1998 and a third-generation orchard in 2010. All trees are showing much improved growth rate.

Hybrid breeding of eucalyptus is now underway for selection of disease resistant genotypes and wide adaptability. Intra-specific hybrids of *E. camaldulensis* Dehnh are common. Clonal tests of inter-specific hybrids between *E. camaldulensis* Dehnh as female parents and other eucalypt species have been planted out. Some hybrid clones have already been used for commercial planting. The breeding for eucalypt hybrids was not well developed because of the lack of information on male and female parental trees.

The improvement program for *E. camaldulensis* Dehnh in Thailand initially placed emphasis on rapid growth of straight and tall trees. An emerging problem with fungal diseases stimulated interest in breeding trees for resistance to common tree diseases. Now there is increasing interest in breeding superior eucalypts which not only grow fast and tall, and survive fungal diseases, but also possess wood with superior pulpwood properties. Such wood will produce much higher economic returns than the average wood which has not been produced from scientifically-directed breeding programs. This work is strengthened with support from Australian Agency for International Development (AusAID) through the Thai-Australia Government Sector Linkages Program. A major goal of the program is to assist the government forest departments and private companies in producing genetically-superior planting materials which will grow quickly and healthily and will also produce a considerable volume of wood with desirable wood properties. An important part of this is the use of Near Infrared Reflectance (NIR) spectroscopy as a rapid method for the routine estimation of pulp properties of wood samples. This information will then be used to select trees with desirable traits for propagation by operational plantations. CSIRO assisted with the required training.

There are more than 300 clones of pure and hybrid *Eucalyptus* species developed by commercial breeding and plantation companies which will be registered with the Plant Protection Division.

c. *Acacia* spp.

More than 20 Australian *Acacia* species have been introduced to Thailand, e.g. *Acacia auriculiformis* A.Cunn. ex Benth in 1935 and *A. mangium* Willd in 1980. More recently in 1985, *A. crassicarpa* A.Cunn. ex Benth and *A. peregrinalis* M.W. McDonald & Maslin (former name *A. aulacocarpa* A.Cunn. ex Benth) were among many Australian acacias imported through the CSIRO Australian Tree Seed Center. These four species have shown the most promise for reforestation in Thailand because of their fast growth and adaptability to a wide range of environmental conditions. The wood of these species is suitable for various applications including paper pulp and furniture. Therefore, these four acacias have been chosen for tree improvement programs by the RFD.

A. auriculiformis A.Cunn. ex Benth

An improvement program for *A. auriculiformis* A.Cunn. ex Benth in Thailand commenced in 1984, focusing on improving the stem form. New genetic resources were imported with assistance from CSIRO. Replicated provenance/progeny trials revealed marked differences in growth and stem form. The program has now entered into the second-generation breeding cycle and the results showed that new imports from Queensland and Papua New Guinea out-performed local unimproved seed in tree volume by up to 5 times (Luangviriyasaeng and Pinyopusarerk, 2002). Intraspecific hybrids of Queensland and Papua New Guinea parents have been developed that showed better growth and stem form. Selection of high pulp-yielding clones will be carried out by the RFD in collaboration with some private companies with financial support from the government - Thailand Research Fund.

A. mangium Willd

A. mangium Willd is proving to be a very versatile species with a wide range of options for both industrial and local utilization. It has become a major reforestation species in the humid tropical lowlands of Asia. Its success is due to its extremely vigorous growth on favorable sites, its tolerance of acidic soils with low nutrient status and its ability to quickly shade out weed competition (Midgley *et al*., 2003).

Plantation of *A. mangium* Willd in Thailand has been carried out extensively by the Thai Plywood company (TPC; state enterprise) with cooperation form Faculty of Forestry, Kasetsart University (KUFF) from 1980. The growth of *A. mangium* Willd planted at different sites was reported by Peawsa-ad and Viriyabuncha (2003).

The improvement program of *A. mangium* Willd in Thailand is less advanced compared to that of *A. auriculiformis* A.Cunn. ex Benth. A breeding population using seedling seed orchard seed of Papua New Guinea origin supplied by CSIRO Australian Tree Seed Center was established at Sakaerat in 1997. Growth performance is currently being evaluated.

A. crassicarpa A.Cunn. ex Benth

The potential of *A. crassicarpa* A.Cunn. ex Benth has yet to be fully explored. It is clearly very useful for pulp. While it has climatic requirements rather similar to *A. mangium* Willd, its adaptability to infertile, high organic soils with a low pH that may be waterlogged occasionally and to very sandy soils where *A. mangium* Willd does not thrive, give it an advantage in these situations (Midgley *et al*., 2003). The first report on pulping and paper-making qualities of *A. crassicarpa* A.Cunn. ex Benth was published (Clark *et al*., 1991, 1994).

Three breeding populations of *A. crassicarpa* A.Cunn. ex Benth in Thailand were established; one in 1996 at Kanchanaburi (west), and two in 2002 at Nakorn Ratchasima (northeast) and Chachoengsao (east). The Kanchanaburi population has been thinned twice to convert it to a seedling seed orchard. The first commercial seed collection commenced in 2005.

***A. peregrinalis* M.W. McDonald & Maslin**

Breeding populations of *A. peregrnalis* M.W. McDonald & Maslin have been established in Thailand. Seed from a first-generation seed orchard is now available. The best sources came from the Fly River (south-east Papua New Guinea), especially those distributed along the Oriomo River, which form a major region of the second-generation breeding population currently being evaluated.

Acacia hybrids (*A. mangium* Willd x *A. auriculiformis* A. Cunn. ex Benth)

The potential of *Acacia* hybrids has been recognized. In Thailand selection of natural hybrids is underway and selected trees have been clonally propagated for field testing. In addition, production of hybrids is being enhanced by mixed row-planting of the two species. Superior hybrid clones will be selected for pulp wood production.

d. Siamese rosewood (*Dalbergia cochinchinensis* Pierre)

The genetic variability of siamese rosewood is greatly threatened. Effective genetic conservation measures are urgently needed to maintain the balance of ecosystems and to provide for present and future uses. A high degree of genetic variability was present in siamese rosewood populations (Soonhuae *et al*., 1994). It was shown that H_e was 0.266 and the mean heterozygosity of siamese rosewood was almost double that of other tropical trees. The proportion of genetic variability among populations was 0.127. The mating system of this species appears to be obligatory outcrossing with a mean outcrossing rate of 99.3%.

The natural distribution of siamese rosewood species in Thailand occurs throughout the central, east and northeast regions. About 300 superior trees have been identified and recorded mostly from the Northeast of Thailand. In the past, small plantations of siamese rosewood were established for the purpose of gene pool and experimental trials. Seed orchards have also been established in Khon Kaen, Kanchanaburi and Nakorn Ratchasima provinces under the RFD Silvicultural Research Division. Some plantations/orchards have already produced seeds for further development of seedling seed orchards. Propagation technology by rooted cuttings has also been developed by which planting stocks are produced from superior trees for further establishment of clonal seed orchards. In addition, some activities in breeding programs have been performed such as controlled pollination and fertilization.

e. *Pinus* spp.

A pine improvement program was set up in 1969 under the technical collaboration between Thailand (RFD) and Denmark (DANIDA). The two local pine species *Pinus kesiya*

Royle ex Gordon and *P. merkusii* Jungh & de Vriese and three exotic pine species *P. caribaea* Morelet, *P. oocarpa* Schiede and *P. patula* Schldl. et Cham. ssp. *tecunumanii* F.Schwerdtf. ex Eguiluz & J.P.Perry were the main focus for the breeding program.

The activities of the pine improvement program are provenance trials, plus tree selection, clone bank, seed production areas and seed orchard establishment. Three provenances each of *P. kesiya* Royle ex Gordon, *P. merkusii* Jungh & de Vriese, *P. caribaea* Morelet and *P. oocarpa* Schiede together with 14 - 19 provenances of *P. patula* Schldl. et Cham. ssp. *tecunumanii* F.Schwerdtf. ex Eguiluz & J.P.Perry were tested in 1971-1972.

A clone bank of 76 plus trees of *P. kesiya* Royle ex Gordon from natural genetic resources and a seed orchard was established by the Pine Improvement Center in Chiang Mai. Four natural stands of *P. kesiya* Royle ex Gordon in Chiang Mai have been converted to a seed production area. There was also a seed orchard of *P. merkusii* Jungh & de Vriese established in Chiang Mai (RFD, 2008b).

f. *Casuarina* spp.

Casuarina species (*C. equisetfolia* L. and hybrid *C. junghuhniana* Miq. and *C. equisetifolia* L.) are among multi-purpose tree species in Thailand that provide a range of products and services from fuelwood to shelter and erosion control. *C. equisetfolia* L. is native to the coastal areas of Thailand while the hybrid was introduced to Thailand in the early 1900s and has become a commercial clonal plantation species for production of piling poles in the construction industry (Chittachumnonk, 1983).

There were five international provenance trials of *C. equisetifolia* L.involving 12 – 55 provenances planted in Thailand in 1992-1994 along with trials in 20 other countries coordinated by CSIRO Australia. The evaluation of these international provenance trials of *C. equisetifolia* L.was reported by Pinyopusarerk *et al*. (2004).

A provenance/ progeny trial of *C. junghuhniana* Miq. was planted in 2004 including seed obtained from 146 individual trees from 15 natural provenances from Indonesia and five planted stands from Australia and Kenya. Results demonstrated considerable variation not only in growth but also stem form, branching habit and flowering among provenances and land races (Luechanimitchit *et al*., 2010). In general low altitude provenances performed better than high altitude provenances.

Two clonal trials of *C. junghuhniana* Miq. of 30 selected trees and a commercial hybrid were established in 2008.

Table 9 Level of the forest tree improvement programs of selected promising species in Thailand

Species		**Level of the seed orchard program**		
Botanical name	**Native (N) or Exotic (E)**	**1st Generation**	**2nd generation**	**3rd generation**
Tectona grandis L.f.	N	✓		
Dalbergia cochinchinensis Pierre	N	✓		
Pterocarpus macrocarpus Kurz	N	✓		
Pinus kesiya Royle ex Gordon	N	✓		
Pinus merkusii Jungh & de Vriese	N	✓		
Phyllanthus emblica L.	N	✓		
Gluta usitata (Wall.) Ding Hou	N	✓		
Aquilaria spp.	N	✓		
Eucalyptus camaldulensis Dehnh.	E	✓	✓	
Eucalyptus urophylla S.T. Blake	E	✓	✓	✓
Eucalyptus pellita F. Muell.	E	✓		
Acacia auriculiformis A. Cunn ex Benth	E	✓		
Acacia mangium Willd	E	✓		
Acacia crassicarpa A. Cunn ex Benth	E	✓		
Acacia peregrinalis M.W. McDonald & Maslin	E	✓	✓	
Pinus caribaea Morelet	E	✓		
Pinus oocarpa Schiede	E	✓		
Casuarina junghuhniana Miq.	E	✓		

* MP : Multipurpose tree improvement program

**NWFP : Non-wood forest product

Table 10 Forest genetic population for improvement programs in Thailand

Species		Plus trees	Provenance trials		Progenies tests		Clonal testing and development			
Botanical name	Native (N) or Exotic (E)	Number	No. of trials	No. of prov.	No.of trials	No. of families	No.of tests	No. of clones tests	No.clones selected	No. clones used
Tectona grandis L.f.	N	500	6	5 - 30	4	130	6	500	20	
Dalbergia cochinchinensis Pierre	N		1	7						
Pinus kesiya Royle ex Gordon	N		3	49	3	101				
Pinus merkusii Jungh & de Vriese	N		1	13	1	49				
Phyllanthus emblica L.	N				4	40				
Eucalyptus camaldulensis Dehnh. and *Eucayptus* hybrids	E				8	>500			315*	
Eucalyptus urophylla S.T. Blake	E				4	145	1	15	4	4
Eucalyptus pellita F. Muell.	E				1	68				
Acacia auriculiformis A. Cunn ex Benth	E		3	25	4	62	8	20		
Acacia mangium Willd	E		1	16	1	89				
Acacia crassicarpa A. Cunn ex Benth	E		1	9	2	80				
Acacia peregrinalis M.W. McDonald & Maslin	E				2	169				
Pinus caribea Morelet	E		3	30	4	288				
Pinus oocarpa Schiede and *P. patula* ssp. *tecunumanii* F.Schwerdtf. ex Eguiluz & J.P.Perry	E				2	90				
Casuarina junghuhniana Miq.	E		1	27	1	150	2	30		

* List number of plus trees if program is beginning and only first generation seed orchards have been established.

The state of use and management of forest reproductive materials; forest reproductive material availability, demand and supply.

The RFD supplied seed from genetic conservation resources e.g. seed orchards, seed production areas, provenance seed stands, selected stands and identified stands. Table 11 list of seed orchards established in Thailand.

Table 11 Seed orchard information of forest genetic resources management in Thailand

Species (Botanical name)	Seed orchards*		
	Region (number of seed orchard)	**Generation	Area (ha.)
Tectona grandis L.f.	North (3)	1st	269.0
	Northeast (1)	1st	456.0
	East (1)	1st	210.0
	West (1)	1st	32.0
Pinus kesiya Royle ex Gordon	North (1)	1st	33.3
Pinus merkusii Jungh & de Vriese	North (1)	1st	2.9
Phyllanthus emblica L.	Center (1)	1st	1.4
	West (1)	1st	1.4
	Northeast (1)	1st	0.6
	North (1)	1st	1.4
Eucalyptus camaldulensis Dehnh.	West (1)	1st	7.0
	East (1)	1st	7.0
	North (1)	1st	8.0
	West (1)	2nd	2.0
	Center (1)	2nd	3.0
Eucalyptus urophylla S.T. Blake	Northeast (1)	1st	2.5
	Northeast (1)	2nd	2.0
Acacia auriculiformis A. Cunn ex Benth	Northeast (1)	1st	2.0
Acacia crassicarpa A. Cunn ex Benth	Northeast (1)	1st	2.0
	West (1)	1st	2.0
	East (1)	1st	2.0
Pinus caribaea Morelet	North (1)	1st	4.86
Pinus oocarpa Schiede and *P. patula* ssp. *tecunumanii* F.Schwerdtf. ex Eguiluz & J.P.Perry	North (1)	1st	4.8
Casuarina junhuniana Miq.	West (1)	1st	2.0

* Seed orchard are plantations specifically planted and managed for seed production not natural seed stands.
** Generation refers to 1st, 2nd , 3rd , etc., breeding cycle.

Table 12 Type of reproductive material available of improvement programs

Species (Botanical name)	Type of material	Available for national requests only		Available for international requests	
		Commercial	research	Commercial	research
Eucalyptus camaldulensis Dehnh.	seed	✓	✓		
Eucalyptus urophylla S.T. Blake	seed	✓	✓		
	clone		✓		
Acacia auriculiformis A. Cunn ex Benth	clone		✓		
Tectona grandis L.f.	seed	✓	✓		
	clone		✓		

Conclusions and suggestion

The management of forest genetic resources in Thailand was developed beginning in 1960. The indigenous species; teak, tropical pine, *Pterocarpus macrocarpus* Kurz, siamese rosewood, *Phyllanthus emblica* L. and exotic species; *Eucalyptus* spp., *Acacia* spp., exotic tropical pine, *Casuarina junhuhniana* Miq. are the main species for improvement programs. *Gluta usitata* (Wall.) Ding Hou and *Aquilaria* spp. are domesticated for non-wood products. Seed and other propagation materials from improvement programs have been released to plantations. Capacity-building of genetic resources management is needed to sustainably use and manage forest genetic resources in Thailand. A regional breeding network of common species in the region will be effective for genetic resources management to save cost and time.

Future needs and priorities

Capacity building of forest tree breeding is needed for sustainable management of forest genetic resources. To exchange the experiences in forest genetic resources management among countries is also important to improve the process of genetic resources management. Regional breeding network of common interested species in the region will be an effective approach for genetic resources management in order to save cost and time. Conservation of genetic resources of species that are commercially important to the region is also needed to secure germplasm for future breeding program.

Chapter 5

The State of National Programs, Research, Education, Training and Legislation

National Programs

The national forest policy of Thailand promotes a forest area of 40 % of the country, including 25 % of total land area for conservation forests and 15 % for economic forests. The conservation forests are designated as protected areas, mainly national parks and wildlife sanctuaries, for better preservation of biological diversity with strict laws and regulations. Formerly, the key institute directly responsible for forest genetic resources was the RFD which was founded in 1896, followed by a restructuring in 2002 to be RFD, DNP and DMCR. Other organizations that are indirectly involved in forest genetic resources are as following.

Ministry of Natural Resources and Environment (MNRE):

- ONEP supports natural resource and environmental enhancement through the development of conservation management plans and policies. Under the ONEP, the Office of Biodiversity Conservation was established with responsibility for national and international cooperation for biodiversity conservation activities.
- The Pollution Control Department regulates, supervises, directs, coordinates, and evaluates rehabilitation, protection and conservation of environment quality.
- The Department of Environmental Quality Promotion carries out research, training development, public awareness activities, and development of environment technology, natural resources and environment.

Ministry of Agriculture and Cooperatives (MOAC):

- The Land Development Department is responsible for land-use planning. Several categories of forestry land uses are included in its land-use-related work.
- The Agricultural Land Reform Office is responsible for declassifying large areas of state forest land for distribution to farmers.
- The Office of Agricultural Economics collects statistics and conducts economic studies concerning agricultural crops, including forestry information.
- The Office of the Rubber Replanting Aid Fund is responsible for the development of rubber plantations.
- The Office of Marketing Organization for Farmers is a possible alternative for developing markets for forest products.

- The Department of Agriculture is responsible in research and development for better plant genetics for transfer to the people and for controlling plant genetic import and export.

- Office of Agricultural Extension is responsible in transferring appropriate technologies to rural communities.

Other Ministries/agencies:

- The Ministry of Interior: The day-to-day operations of province and district forest officers of the RFD are supervised by the Office of the Governor of the different provinces. Presently, the governor is still responsible for forest resources in the province with the work carried out by the office of Provincial Natural Resources and Environment. The Office of the Governor is under the Ministry of Interior's Department of Local Administration. The Forest Policy Unit of the Police Department assists in forest protection and control of illegal activities.

- The Ministry of Industry and the Ministry of Commerce are responsible for promoting forest-based industries and domestic and overseas trade by those industries.

- The NESDB prepares and promotes the NESDP on a five-year cycle, formulates policies to implement the plans and assesses the progress of forest development programs to ensure their consistency with the plan.

- Biodiversity-Based Economic Development Office (Public Organization) or BEDO was founded by Royal Decree on B.E. 2550 (or July 17, 2007). Its responsibility is to promote, to support and to implement measures for the development of a biodiversity-based economy and also for the conservation of biodiversity resources and the traditional knowledge of communities and local communities.

There are also state enterprises involved in the forestry sector. The FIO is involved in reforestation, management of teak plantations, operation of sawmills, and development of forest villages. FIO took over TPC and more improved materials and industrial outputs are expected.

Networks

National collaborative networks are involved in the management, administration and use of forest genetic resources in Thailand. Key departments, including the RFD and DMCR, are responsible in *ex situ* and *in situ* management. Meanwhile, the DNP is mainly involved with *in situ* management. Additionally, the key departments also cooperate with universities, such as the KUFF and the Forest Restoration Research Unit, Chiang Mai University in terms of management approaches and man power development. Other stakeholders involved in this matter include, the Center of Forest and People formerly named Regional Community Forest Training Center for Asia and the Pacific (RECOFTC), NGOs, community leaders in all regions and the Biodiversity Office, MNRE.

Education, Research and Training

Research

Ministry of Natural Resources and Environment (MNRE) Forest Research Units

Forest research in Thailand began ten years prior to the founding of the RFD in 1896 in order to develop knowledge on the extent of teak resources. For the early decades, research emphasized the management of natural forests. Four Lac Regional Silvicultural Research Stations were established in 1952, and others were added subsequently. The TIC in Lampang and the Pine Improvement Center in Chiang Mai were established with Danish supported. Four research stations were also established. Some collaborative research projects were carried out with the support of a number of developed countries and international organizations. These research efforts represented a major public sector investment in forest development.

After the restructuring of the RFD in 2002, forest research offices were established under the RFD, the DNP and the DMCR as the 3 major forest-related Departments under the MNRE. The DNP concentrates on forest conservation research and biodiversity surveys, while RFD research mainly focuses on *ex situ* conservation and utilization of forest genetic resources. The DMCR specializes in marine and coastal research. Even though a forest research institute has been planned and discussed among relevant departments to be established as a center for serving all aspects of forest research and enhancing multi-disciplinary research and extension for the 3 departments, so far this goal has not been achieved. Therefore, this effort should be further developed in order to fill in gaps and enhance harmonization and capacity-building in all aspects of research on forest genetic resources. This research effort should be in line with national policy and should include hot issues related to regional problems and concerns, as well as relevant conventions such as CBD, UNFCCC and CITES. In order to fulfill these goals, international collaboration and networks on forest genetic research should be established at national, regional and global levels.

Universities and other bodies

The Faculty of Forestry at Kasetsart University (KUFF) conducts research in important areas covering forest management, silviculture, forest biology, wood products, watersheds, and forest engineering including forest plant genetic resource conservation and management. The Faculty is actively engaged in inter-disciplinary research and educational activities on critical issues of sustainable forest management and utilization. The research program is conducted by individual faculty members through the Forest Research Center (FRC), a national center for research and development in all the fields of forestry. The FRC has 67 staff members with 58 percent holding PhD degrees.

Areas of current and future research in the FRC include (a) community-based ecotourism, (b) forest fire policy analysis, (c) remote sensing and GIS applications in resource planning, (d) protected area system analysis and planning, (e) mechanical properties of rubberwood, (f) agroforestry, (g) highland reforestation, (h) biodiversity of forest insects, (i) watershed modeling, and (j) mangrove ecology and coastal zone management. KUFF has two research stations, one located in Chiang Mai and the other in the South. Research funding is mainly through the Kasetsart University Research and Development Institute (KURDI). Funds for forestry research have been quite limited; at present forestry represents only 2 percent of the KU research budget. In addition to KUFF and the RFD, research on different aspects of forestry is also conducted by other state and private sector institutions. Chiang Mai University and the Farming Systems Research Institute of the Department of Agriculture conduct research on upland and highland farming systems. Khon Kaen University and the Chulalongkorn University Social Research Institute conduct research on community forests. Research on environmental conservation and medicinal plants has been carried out by Mahidol University. Research on medicinal plants and mushroom diversity has also been conducted by Naresuan University. The FIO has conducted research on commercial teak growing, fast-growing trees, nursery techniques, utilization of teak thinning and agroforestry. Studies are also being done by the private sector, particularly on forest plantation development which are being undertaken by Thai Cement Company Limited, Phoenix Pulp and Paper Company Limited and the Kitti Plantation Company Limited..

Various NGOs are also carrying out valuable research on site-specific issues. Some NGOs have also conducted policy analyses to define their agendas. These have served as valuable inputs for the policy process since other research on policy issues is limited.

Research funding

The organizations mainly responsible for research funding that support the field of forest genetic resource of Thailand are as following.

Office of National Research Council of Thailand (NRCT)

The NRCT is under the supervision of the Prime Minister who plays the role of chairman of the Council. The NRCT is responsible in major vision: (1) to establish policy and strategic in national research; (2) to develop research standards, systems, monitoring and evaluation; (3) to report the national research status and index; (4) to operate a research data center in order to provide comment and suggestions to the government and concerned agencies using information network facilities; (5) to promote research cooperation within the country and other foreign countries; and (6) to promote and provide support for research and invention and to transfer those findings for social, industrial, and commercial development.

Expenditures for research and development have been provided for the fields of pure science, engineering and technology, medicines and health science, agriculture, social science, humanities, and others. The research organizations include government, universities, state enterprises, private sector and non-profit organizations. Based upon the 2009 survey of the NRCT expenditures and personnel for research and development in Thailand, most of the budget (about 60 %) was provided for the fields of engineering, technology and agriculture (as shown in Table 13). Meanwhile, the budget for the fields probably related to forest genetic resources was only about 17 % of the total budget. Therefore, the real budget, which possibly transferred directly to forest genetic resources could be less than expected.

Table 13 Expenditures in research and development in 2009

Major field	Operations organization					Total
	Government	Universities	State enterprise	Private sector	Non-profit	(Unit: Baht)
Pure science	378,044,378 1.76%	969,469,279 4.51%	20,391,497 0.09%	2,192,000,000 10.20%	9,175,508 0.04%	3,569,080,662 16.60%
Engineering and Technology	745,775,149 3.47%	1,307,402,795 6.08%	386,869,550 1.80%	4,305,000,000 20.03%	438,224 0.00%	6,745,485,718 31.38%
Medicines and Health science	663,692,444 3.09%	877,328,338 4.08%	210,090,189 0.98%	700,000,000 3.25%	700,000,000 3.25%	2,464,271,371 11.46%
Agriculture	4,382,074,799 20.39%	770,782,417 3.59%	43,596,339 0.20%	817,000,000 3.80%	19,332,394 0.09%	6,032,785,949 28.07%
Social science	494,952,777 2.30%	1,580,989,250 7.36%	83,293,982 0.39%	120,000,000 0.56%	208,880,151 0.97%	2,488,116,160 11.58%
Humanities	9,512,794 0.04%	143,241,902 0.66%	0 0.00%	27,000,000 0.13%	0 0.00%	179,754,696 0.84%
Others	0 0.00%	0 0.00%	0 0.00%	14,000,000 0.07%	0 0.00%	14,000,000 0.07%
Total	6,674,052,341 31.05%	5,649,213,981 26.28%	744,241,557 3.46%	744,241,557 3.46%	250,986,677 1.17%	21,493,494,556 100.00%

Source: Survey report on the NRCT-funded expenditures and personnel for research and development in Thailand in 2009

The Thailand Research Fund (TRF)

The TRF was established in response to the 1992 Research Endowment Act. It is a juristic body that enjoys being part of the government system, but it is outside the government administrative bureaucracy. This freedom allows great efficiency in research support. The objectives of the TRF are: (1) to build up professional researchers and strengthen the research community; (2) to support research that is significant to national development, both for basic research and research where results can be used directly; (3) to promote the dissemination and use of research findings; and (4) to raise funds for the national research and development system.

Biodiversity Research and Training Program (BRT)

The BRT is supported by the TRF and the National Center for Genetic Engineering and Biotechnology, National Science and Technology Development Agency. It is responsible for providing support in both basic and applied research, including the development of new generation personnel to strengthen the knowledge base in the field of biodiversity.

Education

There are several universities in the country that offer Bachelor's and Master's degree courses related to forest and natural resources, but with different emphases on technical subjects. These include Kasetsart University, which offers courses on forestry, agriculture and fisheries, Chiang Mai University, known for courses on farming systems and natural resource management, and Khon Kaen University, for courses on rural development and regional planning. Similarly, Mae Jo University offers courses on land uses and ecotourism, and Chulalongkorn University offers courses on community development (in which community forestry is a part of the course curriculum).

Kasetsart University has the only full-fledged forestry faculty in the entire country. It offers BSc, MSc, and PhD programs in forestry and related subjects. The four-year BSc program presently includes three specific concentrations. These are forestry, wood sciences and technology, and pulp and paper technology. The forestry course covers: forest resource management, forest engineering, social forestry and forest biological sciences.

The MSc programs, which started in 1967, include four specialized subjects: forestry, parks and recreation, forest resource administration and tropical forestry. The forestry program has five major areas of specialization, including forest management, forest biological science, forest products, watershed management and silviculture. The MSc program on forest resource administration also includes a special weekend program, designed to accommodate people who cannot attend regular weekday classes.

The PhD program in forestry, which was initiated in 1992, focuses on five subjects: silviculture, forest management, watershed and environment management, forest ecology and tropical forestry (an international program conducted in English). There seems to be no problem for forestry graduates in finding jobs as they become easily employed by various departments of MNRE, by NGOs and by the private sector. The majority of the forestry professionals in the MNRE are reported to have studied at Kasetsart University.

Training

Prior to splitting into three departments, the RFD had a training division, with several training centers in different regions of the country. The most important ones included the training centers located at the central office in Bangkok and those in Phrae Province, Khao Yai, Cha Am, Chiang Rai and Tak Provinces. However, following the MNRE's decision to restructure the RFD, the training division was removed, placing all the respective human and financial resources and facilities under the DNP. According to the DNP's training plan for 2005-2006, activities (meetings, workshops and seminars) cover such topics as orientation training for newly recruited staff, training of trainers, management and services, conflict management and negotiation, insect inventory/survey techniques, forest fire control, environmental impact assessment after forest destruction, forest law and enforcement, forest criminal case investigation, tools and techniques for financial analysis, youth camp trainers, GIS, database management, appropriate morals (King's birthday), research, development strategy for the DNP and refresher courses for senior government officials, etc. In total, some 150 activities are planned and carried out each year involving over 3,000 trainees.

The main constraint facing further training is that all the resources have been assigned exclusively for the training of the DNP staff. This overlooks the training needs of the staff working in the RFD and other departments. The RFD staff (more than 4,000) responsible for the management of national forest reserves, promotion of community forestry and private reforestation, are completely deprived of further training opportunities.

National Legislation

Thailand has established legislation and regulations relevant to forest genetic resources as following.

- Forest Act B.E. 2484 (1941) was enacted concerning logging operations and the collection of non-wood forest products, transportation of timber and non-timber products, sawn wood production, and forest clearing.

- National Parks Act B.E. 2504 (1961) was enacted to conserve natural resources and to maintain their natural status as well as to prevent their destruction and transformation. The Act also covered the determination of national park land, the National Park Committee, and the protection and maintenance of national parks.

- National Forest Reserve Act B.E. 2507 (1964) was enacted to protect forest resources. It was also including the determination of national reserved forests and their control and maintenance.

- Wildlife Conservation and Protection Act B.E. 2535 (1992), (abolished the Wildlife Conservation and Protection Act 1960) was enacted to establish provision for the preservation of the nation's wildlife, to establish the Protection Committee and to identify 15 species of reserved wildlife.

- Forest Plantation Act B.E. 2535 (1992) was enacted to provide incentives to the private sector to run tree-plantation businesses. The Act covered the determination of reforestation, land registration of private reforestation, ownership and rights, and the royalty on forest products from reforested area.

- In 2002, the Chain Saw Act (B.E. 2545) was enacted with appropriate guidelines for chain saw control and was an important deforestation instruments.

Information Systems

The key departments involved in forest genetic resources namely the RFD, the DNP and the DMCR have developed web-based information systems that are available in both spatial and non-spatial formats. Datasets have been provided separately for public and other concerned organizations in forest genetic resources conservation and management.

Public Awareness

Extensive efforts to increase public awareness on aspects of the importance of forest genetic resources conservation and management have been conducted in Thailand. Several campaigns have been conducted on afforestation, reforestation, and tree plantations at specific or special occasions. These have included the reforestation campaign within the Commemoration of the Royal Golden Jubilee, a tree planting campaign for the public as well as the private sector. In the private sector, tree planting is implemented by major companies for industrial purposes and also by community associations which have established woodlots and integrated land use systems. City greening campaigns have also been emphasized, and public awareness has been raised through forest community activities.

Conclusion and suggestion

The DNP, RFD and DMCR should promote national conservation and sustainable use of forest genetic resources holistically. A long-term research fund should be established to provide a robust database and predict the trends of change of forest genetic resources and forest types including new species. The establishment of a database system, appropriate amendment of laws and continuity of public awareness and information campaigns on protection and conservation of forest genetic resources at all education and community levels could fulfill the achievement of this effort.

Chapter 6

The State of Regional and International Collaboration

International collaboration program and projects on genetic resource conservation

The collaborative research projects evaluating the genetic diversity of forest trees species have been initiated during the previous 2 decades between RFD, the DNP and universities in Germany and gradually with Sweden, Japan and Australia and up to present with Denmark. Outcomes of these research collaborations were shown in the references in Chapter 1. International botanical collaboration on a large scale began with the establishment of the Flora of Thailand Project in 1963 under Thai–Danish collaboration. The aim was to produce a complete floristic treatment of the entire vascular flora. The first volume was published in 1970 and additional volumes have been produced regularly since then in collaboration with other herbaria and botanical institutes in Europe, Asia and Thailand. To date, 200 families in 34 volumes have been published. It is hoped that the Flora can be completed within approximately 20 years (2030). One of the main barriers is that a lot of biological systematic information in *ex situ* collections is mainly deposited in Europe, especially type specimens. In 2012, the Forest Herbarium (BKF), Department of National Parks, Wildlife and Plant Conservation and the Bangkok Herbarium (BK) began participating in the Global Plant Initiative (GPI), an international collaboration between herbaria to digitize and make available plant type specimens. Currently, there are 175 partners in 60 countries. Thailand is the second partner working in Asia and will provide approximately 1650-1700 type specimens held in the collections of BKF and BK. The output of GPI is presented on the JSTOR Plant Science website making all information freely accessible to participating members. This will facilitate research on the Flora of Thailand and speed up the completion of a published Flora which is necessary for a nationwide policy on sustainable use and conservation of Thailand's genetic resources. Some international collaboration programs and projects are shown in Table 14.

Sub-regional and regional collaboration and networks on forest genetic resources

In 1981, the ASEAN-Canada Forest Tree Seed Center was initiated by the Canadian International Development Agency (CIDA) in cooperation with Natural Resources Canada. The Center, located in Muaklek District of Saraburi Province, plays a major role as a seed source conservation center of forest trees. This center was the first Canadian-financed ASEAN institutional initiative of the region. After sixteen years of CIDA support, the Center has developed an international reputation on research of genetic variation of native species while gaining an Asia-wide reputation as an excellent resource for tree seed information and training site (ASEAN, n.d.). This Center has been reconstructed and assigned as a forest tree seed center under the responsibility of the RFD.

Numerous international collaborations for regional programs have been initiated under the responsibility of the RFD, DNP, and DMCR of Thailand. The FAO, DANIDA, CSIRO, ITTO and other international organizations have joined with Thailand to conduct activities such as the teak-network, neem-network, chukrasia-network. Thailand also has activity with the bamboo and rattan network (INBAR) but has not yet become a member of this network. These international networks provide for collaborative research and conservation of seed sources and genetic and tree improvement. Since the 1970s, DANIDA has supported the RFD establishing pine and teak improvement centers in Chiang Mai and Lampang province which are considered as outstanding places for training and study visit sites for both local and international researchers.

The teak, pine and neem networks are not as active in Thailand as previously, due to financial constraints of the responsible agency. However, the international provenance trails of teak, pine and neem are still in excellent condition and serve as good genetic resources for further research on genetic diversity and breeding programs, as well as for scientific visits. Thailand will host the world teak conference on 25-30 March 2013. The meeting will provide opportunities to review previous teak-related activities/research and to project future activities and research collaboration among the countries in the region, other relevant countries and international organizations. Tentative topics to be presented and discussed at the conference include environment, climate change and carbon trading.

The Asia Pacific Forest Genetic Resources Program (AFROGEN), for which the RFD is the national focal point, has indicated an active status for international networks in Thailand. It is important to maintain and continue this network for future work while it is also important to develop and improve additional collaborative activities and research programs among all relevant departments and stakeholders, namely the RFD, DNP, and DMCR.

A pilot project on biodiversity conservation with a landscape planning approach to address current and emerging environmental challenges, has been implemented with an ADB-supported grant to Thailand. Thailand joined the Greater Mekong Subregion Biodiversity Cooridor Initiative (GMS-BCI) during2006 -2009. Sub-regional and regional collaboration on forest genetic resources are listed in Table 15.

Current ratified Conventions of Thailand

During the past 10 years, Thailand ratified numerous international agreements and conventions for sustainable development and conservation of forest genetic resources. The CBD, UNFCCC, United Nations Convention to Combat Desertification (UNCCD) and CITES, as well as other protocols and international conventions are shown in Table 16. The impacts of these agreements with regard to the conservation and sustainable use of forest genetic resources are summarized.

Convention on Biological Diversity (CBD)

Thailand signed the CBD on 12 June 1992 at the Rio Conference on Environment and Development (UNCED). Thailand ratified the CBD in October 2003. The Convention became effective on 29 January 2004, making Thailand the 188th Contracting Party. The Government of Thailand then announced the year of 2010 to be Thailand’s Year of Biodiversity, in line with a resolution of the United Nations General Assembly (UNGA), which declares 2010 as the International Year of Biodiversity (IYB).The Thai Cabinet, during its meeting on 22 December 2009, approved the announcement proposed by the National Committee on Conservation and Sustainable Use of Biodiversity including recommendations made by the Ministry of Natural Resources and Environment (MNRE). It also endorsed the Action Plan for IYB and instructed all relevant government offices to allocate funds for its organizations to operate in accordance with the action plan. The objective of the resolution was to urge people from all groups and professions to be aware of biodiversity and to cooperate in conserving and using biodiversity in a sustainable way. In this matter, the MNRE informed the Cabinet that the UNGA made the Declaration to coincide with the 2010 Biodiversity Target adopted by the Parties to the CBD and by heads of state and governments at the World Summit for Sustainable Development in Johannesburg in 2002 (CBD, 2010).

United Nations Framework Convention on Climate Change (UNFCCC)

Thailand has recognized the significance of climate change and global warming by becoming a member of the UNFCCC on 28 December 1994, and later ratifying the Kyoto Protocol on 28 August 2002. As a result of the ratification of this agreement with the UNFCCC, Thailand was placed in the “Non-Annex I” category, a non-binding treaty which has set no strict limitations on greenhouse gas emissions and enforcement conditions upon the member nations (ONEP, n.d.).

At present, the UNFCCC is a good platform to provide opportunities to reduce forest cover loss and to promote forest conservation through a new mechanism named Reducing Emissions from Deforestation and Forest Degradation in Developing countries (REDD+) which increases the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. REDD+ will provide incentives to developing countries in the form of financial support and technology to build capacity on forest monitoring systems and for implementing programs to reduce forest cover loss and promote forest conservation, sustainable management of forests and enhanced forest carbon stocks through local community participation. However, information and knowledge dissemination to local communities, especially to forest dependants, should be strengthened. The process should be done though relevant stakeholder consultation. Presently, methodologies for monitoring, reporting and verification (MRV) and details on financing are awaiting further negotiations by the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Ad hoc Working Group on Long-term Cooperative Action (AWG-LCA) under the UNFCCC for the coming year.

The convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)

In 1983, Thailand ratified the CITES and became the 80th member of the Convention. CITES-Thailand has been effective in dealing with trade in plants according to the CITES System, especially wild orchids, cycads species and tree ferns (Vessabutr, 2005).

As a consequence, Thailand hosted CITES COP 13 in 2004 and will be the host country again for CITES COP 16 in 2013 in Bangkok. This contribution and effort shows that Thailand demonstrates its concern on the problem of the international illegal trade of endangered of flora and fauna and considers that one way to cope with this problem is through international cooperation under this convention.

In particular, endangered species in Thailand which contain economic value such as siamese rosewood are now under extreme pressure from international illegal trade in the region. Thus, such species are now under the process of consultation among relevant stakeholders in order to consider whether this species should be submitted to CITES COP16 for insertion into the list of annexes under this convention.

The United Nations Convention to Combat Desertification (UNCCD)

The Convention aims to combat and mitigate desertification in those countries experiencing serious drought and/or desertification, particularly in Africa through national action programs that incorporate long-term strategies supported by international cooperation and partnership arrangements. UNCCD, which stemmed from a direct recommendation of the Rio Conference's Agenda 21, was adopted in Paris on 17 June 1994 and entered into force in December 1996. It is the first and only international legally-binding framework set up to address the problem of desertification. UNCCD is based on the principles of participation, partnership and decentralization – the backbone of good governance and sustainable development. It now has 194 country parties to the Convention, making it truly global in reach.

Thailand recognized the significance of this convention by becoming a member of the UNCCD on 5 June 2001. Currently, the Land Development Department under the MOAC has been assigned the role as the National Focal Point of this Convention (UNCCD, 2009).

The Convention on Wetlands (Ramsar)

The Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Furthermore, the Ramsar Convention is the only global environmental treaty that deals with a particular ecosystem. The treaty was adopted in the Iranian city of Ramsar in 1971 and the Convention's member countries cover all global geographic regions.

The Ramsar came into force for Thailand on 13 September 1998. Thailand presently has 12 sites designated as Wetlands of International Importance, with a surface area of 375,445 ha (ONEP, 2012).

Future challenge for international collaboration regarding forest genetic resource conservation

To improve the effectiveness of international collaboration regarding forest genetic resource conservation and management, the needs and priorities to promote and improve international collaboration are considered to be ranked as following:

1. Understanding the state of diversity
2. Enhancing *in situ* conservation and management,
3. Enhancing *ex situ* conservation and management,
4. Enhancing use of forest genetic resources
5. Enhancing research,
6. Enhancing education and training
7. Enhancing legislation
8. Enhancing information management and early warning systems for forest genetic resources.

   If sufficient financial support from international organizations is provided, all those activities mentioned above can be jointly conducted in the same project by carefully choosing priorities species and hot spot ecosystems.

Meanwhile, Thailand's development vision has increasingly emphasized the social dimension to cope with the effects of globalization. The country needs to integrate the problem of global warming, biodiversity deterioration, desertification and other international agreements to protect natural resources such as CITES into its policies and plans for national sustainable development. Incorporating international environmental phenomena is a new challenge for the Thai Government as it pursues the country's sustainable development.

Table 14 International programs and projects for forest genetic resources over the past 10 year till present and the main results/outcomes and benefits to Thailand

List of international programs	**Time Frame**	**Responsible Department**	**Main results and outcome**	**Benefits to Thailand**	**Sponsors**
1. FORGENMAP (FORGENMAP, 2002a)	1997-2002	RFD	1) Developed Seed Documentation System 2) Developed Seed Sources Classification 3) Establishment of seed sources 4) Report of conservation of some tree species	1) Bring awareness of seed quality to tree planters and stakeholders 2) Develop seed management in terms of seed sources, seed procurement 3) Enhance manpower capacity 4) Conservation of some major species	DANCED
2. Supporting Country Action on the CBD Program of Work on Protected Areas (DNP, 2008b)	2003 – 2008	DNP	A National Protected Areas Master Plan for the establishment of an effective system of protected areas for Thailand pending Cabinet adoption	Develop a National PA Master Plan as a long-term legal and programmatic document for the PA system.	1) GEF 2) Co-financing total, including : Government NGOs
3. To Develop and Promote a Monitoring Information System to Support the Sustainable Management of Tree Resources Outside Forest at the Sub-District Level in Thailand (DNP, 2010b)	2008-2011	DNP	1) TROF uses and formations defined. 2) TROF inventory and monitoring information system developed. 3) TROF inventory and monitoring information and sustainable management promoted.	Contribute to the sustainable development of TROF to provide maximum socio-economic and cultural benefits to the rural people.	ITTO
4. Andaman network marine protected areas management effectiveness, and sustainable tourism program. (DNP, 2007)	2005-2007	DNP, WWF	1) Knowledge, skills and abilities of staff in 3 MPAs improved against 2006-2007. 2) Improved nature education, information and awareness-raising facilities, activities, and materials developed and used. 3) MPA Andaman Network Regional	Strengthen the MPA network on the Andaman and secure conservation durably, reduce the impacts of tourism and develop best environmental practices from private operators.	AFD, FFEM

Table 14 (Cont.)

List of international programs	Time Frame	Responsible Department	Main results and outcome	Benefits to Thailand	Sponsors
			GIS Unit established- Monitoring of natural resources and biodiversity improved (including impacts) 4) Improved Enforcement of park laws and regulations. 5) Revenues of MPAs increased and allocations better managed. 6) Management Plans implemented, reviewed and updated in a participatory manner. 7) Mokan(Sea Gypsies) communities on Surin Island improved sustainable livelihood opportunities and improved partnerships with the MPAs. 8) Green Leaf organization labeled more hotels and developed new services. 9) Tourism sector developed specific partnerships with MPAs on Andaman Coast. 10) New DNP regulations reduced tourism impacts on MPAs. 11) Green Fins standards applied to Divers and snorkeling companies. 12) CDM project was a complementary tool for tourism sector efforts on environment.		

Table 14 (Cont.)

List of international programs	Time Frame	Responsible Department	Main results and outcome	Benefits to Thailand	Sponsors
5. ACIAR					
5.1) Australian Hardwoods for fuelwood and Agroforestry: Project No.8320	1985-1987	RFD	More than 20 field trials were established involving more than 100 species which were tested over 8 sites representing different climatic and soil conditions of Thailand.	-	Government of Australia
5.2) Australian woody species for saline sites in Asia:Project No.8633	1988-1993	RFD	Species with good performance on moderately to highly saline land included *Eucalyptus camaldulensis*, *Melaleuca kajuputi* and *Acacia ampliceps*. Survival and growth decline for *Acacia ampliceps* with age (up to 5 years) was associated with waterlogging and nutrient deficiency. Mulch and gypsum application markedly improved survival and early growth of *Acacia ampliceps*.	Evaluation of a wide range of tree species and establishment techniques for salt-affected land in the north-east of Thailand.	Government of Australia
5.3) Australian hardwoods for fuelwood and agroforestry : Project No.8808	1988-1991	RFD	This was an extension of Project 8320. Promising species (e.g. *Acacia auriculiformis, Acacia aulacocarpa and Acacia crassicarpa* and *Eucalyptus urophylla*) were further studied for their growth, genetic improvement and silvicultural options.	-	Government of Australia
5.4) Improving and sustaining productivity of eucalypts in SE Asia: Project No.9115	1992-1995	RFD	1) Four large progeny trials of *Eucalyptus camaldulensis* involving 315 selected families were established.	-	Government of Australia

Table 14 (Cont.)

List of international programs	Time Frame	Responsible Department	Main results and outcome	Benefits to Thailand	Sponsors
			2) Mixed planting of *Eucalyptus camaldulensis* and *Acacia auriculiformis* was established for future study		
5.5) Predicting Tree Growth for General Regions and Specific Sites in China, Thailand and Australia : Project No.9127	1992-1996	RFD	1) Climatic mapping and simulation mapping programs were developed containing data estimated for thousands of locations across Thailand. 2) A database of Plantgro soil and climate files was developed for 244 representative soil sites across Thailand.	Developed generic methods to assist in the selection of tree species and provenances.	Government of Australia
5.6) Growing on salt-affected land in Pakistan, Thailand and Australia : Project No.9316	1994	RFD	Over 12 months of water use data were obtained for *Eucalyptus camaldulensis* and *Leucaena leucocephala*.	Established international collaboration and knowledge management on *Eucalyptus camaldulensis* and *Leucaena leucocephala* research	Government of Australia
5.7) Minimising disease impacts on eucalypts in SE Asia : Project No.9441	1996	RFD	Susceptible provenances of *Eucalyptus camaldulensis* subjected to chronic defoliation suffer shoot blight and progressive canker development on main crown components and may subsequently die. Badly affected trees were malformed, suffered severe reduction in growth and loss of merchantable volume.	Establish international collaboration and knowledge management on disease impacts on *Eucalyptus camaldulensis*.	Government of Australia

Table 14 (Cont.)

List of international programs	Time Frame	Responsible Department	Main results and outcome	Benefits to Thailand	Sponsors
5.8) Development of domestication strategies for commercially important species of Meliaceae in SE Asia. : Project FST/1996/005	1999	RFD	1) *Chukrasia tabularis* will be used as a pilot species in SE Asia. 2) Floral biology of *Toona* spp. will be a main focus in Australia.	-	Government of Australia
5.9) Project FST/2002/112 (DNP,2008c)	2005-2008	RFD	1) Maintained experimental provenance trails after project termination 2) Selected and propagated mother trees that can resist worm borers	1) Developed proper planting and management techniques 2) Enhanced skills and knowledge of staffs	Government of Australia
6. Evaluating and improving the management effectiveness of Thailand ' s marine and coastal protected areas (DNP, 2009b)		DNP	1) A tailored MEE system was developed and implemented resulting in improved management of Thailand 's MCPAs as a foundation for sustainable development of coastal areas. 2) Capacity was built in DNP on MEE to ensure that adaptive management approaches are fully integrated into Thailand's routine PA management practices. 3) MFF Showcase sites were established in selected MCPAs to demonstrate best practice and inform national approaches to adaptive	Strengthened coastal and marine stewardship in Thailand's marine and coastal protected areas as a foundation for sustainable development.	IUCN

Table 14 (Cont.)

List of international programs	Time Frame	Responsible Department	Main results and outcome	Benefits to Thailand	Sponsors
			management. 4) MFF initiative partners learned from the experiences and findings of the Thai MEE project in replicating the approach at different scales across Thailand and the region.		
7. Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos (Phase II)**.** (RFD, 2007)	2005 - 2006	RFD	1) Strengthened cooperation among the three countries on TBCA. 2) Increased human resource capacity in biodiversity conservation and management. 3) Integratde conservation and development programs in buffer zone and nature-based tourism packages to increase livelihood of local residents and alleviate local poverty.	1) The PPFC protects the head watersheds that supply water to the Sirinthorn and Pak Moon Hydropower dams. 2) The local communities involving in buffer zone management gained additional knowledge on alternative income generation and had the opportunity to express their expectations and share responsibility in natural resources management. 3) Thailand, Cambodia and Laos are recognized by international communities and show commitment in biodiversity conservation as rectified. 4) Each country has more reliable data within its own country and neighboring countries to assist decision-making. 5) Park rangers gained knowledge and effective tools in conservation management planning and had opportunity to interact with park rangers working in adjoining protected	ITTO

Table 14 (Cont.)

List of international programs	Time Frame	Responsible Department	Main results and outcome	Benefits to Thailand	Sponsors
				areas.	
8. UNDP Project Document : Catalyzing Sustainability of Thailand's Protected Area System (DNP, n.d.)		DNP	1) Improved governance supports enabling environment for long term PA system sustainability. 2) Institutional and individual capacities enhanced. 3) Revenue generation mechanisms and management approaches were assessed and tested at 5 PA demonstration sites leading to increased funding levels of the PA system. 4) New models of PA management supported effective management of the system.	1) Overcame barriers to sustainability of Thailand's protected area (PA) system. 2) Built the confidence and capacities of the PA management authorities and provided them with resources to test innovative PA management and financing schemes. 3) Supported development of appropriate incentives, establishment of an effective monitoring system, and community participation in conservation efforts.	UNDP, GEF
9. Enhancing the economics for ecosystem services in South-East Asia: Instruments for biodiversity conservation through payment mechanisms for ecosystem services in designated areas in Thailand as a model for South-East Asian countries. (DNP, 2009c)		DNP	1) Institutional capacities for protected management in selected pilot areas will be strengthened. 2) Findings of TEEB will be introduced in protected area management at national and on-site levels. 3) Existing laws and regulations related to biodiversity conservation will be analysed with recommendations for changes in the legal system.	1) Strengthened biodiversity conservation systems in pilot areas as a SEA model for effective management and innovative financing schemes through improving institutional capacities for protected area in selected pilot areas in Thailand and Laos. 2) Improved framework conditions and initiate new categories of designated areas and promote best practices in the management of ecosystem service and payment systems through national and regional know-how transfer.	GTZ, UFZ*

Table 14 (Cont.)

List of international programs	Time Frame	Responsible Department	Main results and outcome	Benefits to Thailand	Sponsors
			4) International best practices of biodiversity conservation frameworks will be analyzed and reviewed. 5) Best practices concerning zoning for biodiversity conservation will be applied. 6) Competence centers for ecosystem services will be established or improved for on-site and South-East Asian know-how transfer. 7) PES schemes will be derived from international best practices and implemented in 3 pilot sites in Thailand and 2 sites in Lao PDR. 8) Best practices for the payment of ecosystem services will be exchanged through existing regional and international platforms. 9) Develop action plans to foster institutional embedding of successful financing schemes within Southeast-Asia.		

Table 14 (Cont.)

List of international programs	**Time Frame**	**Responsible Department**	**Main results and outcome**	**Benefits to Thailand**	**Sponsors**
10. Flora of Thailand Project	since 1963	BKF	So far, about 50 % of vascular plants in the country have been published (Flora of Thailand volumes 2-12).	Produce a complete floristic treatment of the entire vascular flora in Thailand	Major herbaria in Europe and Asia including AAU, C, E, L, P, M, K, KYO, SING, TCD
11. The Global Plant Initiative (GPI) in Thailand	since 2012	BKF, BK	Project just started in March 2012	Free access to plant type specimens, taxonomic structures, scientific literature and related materials	Andrew W. Mellon Foundation, USA

Table 15 International network (Regional and sub regional forest genetic resources) for over the past 10 years till present and the benefits to Thailand

List of international network	Time frame	Responsible department	International Coordinator /sponsors	Benefits to Thailand
1. INBAR (Bamboo and Rattans)	Since 1985, the Canada's International Development Research Centre (IDRC) supported research activities on bamboo and rattan before the establishment of an independent INBAR in 1993.	RFD (not a member but joining activities)	International organizations such as EU,CFC,GTZ ,ITTO FAO,UNIDO,ADB WWF,WB,DFID USAID,ACIAR K,FINNIDA	1) Received up-to-date information and publications on-line 2) Increased channels of distribution of models derived from various fields of research 3) On-line live communication 4) Attended international conferences, forum, training, workshops, 5) Received special privileges for continuous training programs under INBAR
2. APFORGEN	2006-2010	RFD	ITTO/APAFRI	1) Strengthened capacity for sustainable use of FGR 2) Updated priority species 3) Getting involved in FGR activity internationally 4) Obtained funding support for government officials to join international conferencesand training courses
3. The Greater Mekong Subregion (GMS) Core Environment Program and Biodiversity Conservation Corridors Initiative (CEP-BCI)	2006-2009 and extended to 2011	DNP	ADB, the governments of the Netherlands, Sweden and Finland (joined later), and the Poverty Reduction Cooperation Fund of the People's Republic of China	The goal of the program is to establish sustainable management regimes for restoring ecological connectivity and integrity in a selected set of important biodiversity areas in 5 GMS countries. At 2011, eight pilot sites of biodiversity corridors in five GMS countries have been established. One of these initiatives is located in Thailand at the Tenasserim BCI pilot site. Dong Phayayen–Khao Yai Forest Complex has also been selected as a feasibility site to conduct a feasibility study on options of wildlife corridors connecting Khao Yai and Taplan National Parks.

Table 15 (cont.)

List of international network	Time frame	Responsible department	International Coordinator /sponsors	Benefits to Thailand
				This goal of the program was achieved through implementation of the following objectives at the Tenasserim BCI pilot site; (i) Poverty alleviation through sustainable use of natural resources and development of livelihoods through Village Revolving Fund (ii) Clear definition of optimal land uses and harmonized land management regimes; (iii) Restoration and maintenance of ecosystem connectivity; (iv) Capacity building in government staff and local communities on the above mentioned 3 activities and on sustainable forest resources management (cross cutting activity)

Table 16 List of international agreements, treaties, conventions and trade agreements over past 10 years that are relevant to the sustainable use, development and conservation of forest genetic resources in Thailand.

Number and title of the agreement	**Types of international agreements**	**Ratification Date and Year**	**Impact of these agreement to conservation and sustainable use of forest genetic resources**
1.CBD and its protocols , Catehyna, ABS, Initiatives Global Plant Conservation Initiative, GTI	Convention	31 October 2003	Thailand has established forest biodiversity strategy in order to disseminate information on biodiversity nationwide. This mechanism includes activities to ensure sustainable use of forest resources such as accessibility and benefits sharing. For example; database development, body of knowledge collection, R&D in forest products, networking establishment, monitoring system development, capacity building programs. In particular, domestic flora and fauna have been conserved and propagated to ensure genetic resource stock with participant user groups and communities.
2.UNFCCC, Kyoto protocol: Forestry CDM , SBSTA, AWGLCA: REDD+	Convention Protocol	28 December 1994 28 August 2002	Thailand has previous experience in research and modeling of the impacts of climate change on forest resources. More information would facilitate policy development to counteract the problems regarding climate change, especially on adaptation at the community and national levels. Thailand recognizes the contribution of the REDD+ for both mitigation and adaptation and is exploring the opportunities provided by this mechanism. It is in process to develop capacity building on related technical issues, national strategy and knowledge management at all level of stakeholders. Thailand recognizes the importance of public participation as a key role to achieve reduction of deforestation and forest degradation as well as enhancing forest conservation and sustainable management of forests. As a major mechanism under Kyoto Protocol, Clean Development Mechanism (CDM) has become popular within industrial and energy sectors. Meanwhile, within the forestry sector, reforestation and afforestation programs have been found to be ineffective to prevent GHG emissions from forest area due to a complication in the process of registration for certification and monitoring. No research has yet been conducted to reveal the impacts of the Protocol on forest genetic resources in this case.

Table 16 (cont.)

Number and title of the agreement	Types of international agreements	Ratification Date and Year	Impact of these agreement to conservation and sustainable use of forest genetic resources
3. CITES	Convention	Since 1983	1) Protecting endangered and threatened species of flora and fauna from illegal poaching and harvesting 2) Establishing networks such as ASEAN-WEN and Thai-WEN for protecting endangered and threatened species of flora and fauna including their products from global trade
4. UNCCD	Convention	5 June 2001	Thailand expressed her desire attempt to participate with international committees for solving land resource deterioration in order to eradicate poverty and maintain environmental quality. Activities under UNCCD are crucial for cooperation of all development programs of the UN such as RIO 21, poverty eradication as well as achievement target of sustainable Millennium Development Goal. Thailand has also included within affected countries from dessert transformation and drought so that the country has the right to gain support in terms of finance, research, technology and technical expertise from the international community. This assistance can advance bring the development of implementation of according to the commitment of the convention. Meanwhile, lessons learned from success stories of member states of the convention can be brought to adapt for project implementation with in the country.
5. Ramsar	Convention	13 September 1998	1) Increased conservation while halting degradation of wetlands in each region of the world 2) Mitigated conflict in international conservation and utilization of wetlands including various types of living organisms and seasonal migration birds which has specified within the convention that all member states have to cooperate in the management of shared wetlands and living organisms. 3) Enhanced wise use of of wetlands and living organisms due to the convention's specification for the coordination of all member states to enact wetland conservation and establish national land-use management plans 4) Increased protection of registered wetlands through regular monitoring and evaluation to prevent degradation by regular monitor and evaluation.

Chapter 7

Access to Forest Genetic Resources and Sharing of Benefits Arising from their Use

As assigned by the MNRE, the DNP was established to be responsible mainly for protection and conservation of protected forests, whereas the RFD is responsible for conservation and utilization of reserve forests. The DMCR has the primary role in conservation and utilization of the marine and coastal area that may be either protected or reserved areas. The main laws that are involved in overall management of forest genetic resources and enforced by those Departments include: **1) Forest Act B.E. 2484 (1941); 2) National Park Act B.E. 2504 (1961); 3) National Forest Reserve Act B.E. 2507 (1964); and 4) Wildlife Conservation and Protection Act B.E. 2535 (1992).**

Access to Forest Genetic Resources

Thailand ratified the CBD on October 31, 2003. The CBD entered into force on 29 January 2004. As a Party to the CBD, Thailand has established and set up important mechanisms and structural organizations to provide support and compliance to the principles of CBD on conservation, sustainable utilization and benefit-sharing of genetic resources. The ONEP under MNRE is assigned as the National Focal Point to CBD and a number of Departments and Offices, such as DNP, RFD or DMCR, are considered as implementing agencies. At the 10th Conference of the Parties to CBD, the legally-binding instrument, the so-called Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization was adopted, with all parties called to sign the Protocol by February 2012. Thailand has already signed the Nagoya Protocol and has currently undergone a number of investigations and preparations, including stakeholder consultations, investigation of laws and regulations in relation to Access and Benefit-sharing (ABS), as well as identification of national mechanisms, procedures and national competent authorities.

In connection to the principles of the Nagoya Protocol, especially the principles of Prior Informed Consent (PIC) and Mutually Agreed Terms (MAT), Thailand issued and declared an important regulation in March, 2011 that supports access to genetic resources and benefit-sharing in Thailand--the Regulation of the National Committee on Biodiversity Conservation and Utilization on Criteria and Approaches of Access to Biological Resources and Benefit Sharing from Their Use B.E. 2554 (2011). This is considered as an important step for Thailand to implement provisions on ABS under the CBD and the Nagoya Protocol. The Regulation is applied for governmental organizations mandated by laws in regulating biological resources and reserve and protected areas, and/or having biological resources in possession, which do not have clear mechanisms or processes to ABS. The Regulation contains a clear concept of PIC and MAT and detailed procedures in obtaining access permission and enters into benefit-sharing agreement, both for commercial and non-commercial purposes, with an exception for non-commercial research projects under academic curriculum, in which benefit-sharing agreement may not be needed.

With respect to access to forest genetic resources, the RFD, DNP and DMCR have different concepts and mechanisms, enforced by laws and regulations, relevant to accessing genetic materials. Under the National Park Act and Wildlife Preservation and Protection Act of the DNP, it is strictly stated that persons or institutions are not allowed to collect forest genetic materials in protected forest areas, particularly, in national parks, wildlife sanctuaries and non-hunting areas. Only officers that have been legally assigned by the DNP or are under the Ministerial Regulations of MNRE are allowed to do so. However, to support the conduct of research in protected forest areas, Guidelines for Permission to Do Research or Study in Protected Forest Areas under responsibility of the DNP are in effect. Researchers from academic institutions or organizations may apply for permission to conduct research projects in protected forest areas of national parks, wildlife sanctuaries or non-hunting areas. However, permission to collect any forest genetic material under such projects will be granted to assigned officers only. On the other hand, researchers can gain admission into the area under conditional permission only to provide support and academic and technical advice to implement the research projects.

To access forest genetic resources of reserved forests under the responsibility of the RFD, the RFD Regulation on Permission to Implement Activities on Research or Study Purpose in Reserve Forest 2005 under the Reserve Forest Act was declared. For such activities, researchers are allowed to gain access to forest genetic resources in reserve forests only under certain permitted conditions. For example, research may be conducted under supervision of the assigned officers during a limited permitted period of access or making declaration of forest genetic materials collected. In the case of access to forest genetic resources in peat and mangrove forests which are under the responsibility of DMCR, access depends on whether the forest area is either protected or reserved. In such case, the relevant laws and regulations will be enforced.

In other cases, some community forests throughout the country are considered as high biodiversity and potential forest genetic resources. They are normally accessible to local communities in terms of the collection of dead wood and non-wood forest products, e.g. mushrooms, bamboo shoots or wild plants for their household consumption and livelihood. In addition, well-organized local communities establish mechanisms or regulations to support sustainable utilization and conservation of the forest genetic resources.

Sharing of Benefits Arising out of Forest Genetic Resources

Due to strict restrictions on access to forest genetic resources in protected forest areas enforced by the National Park Act and the Wildlife Preservation and Protection Act of DNP, no mechanisms or guidelines regarding benefit-sharing arising from use of genetic resources has been made. Further, even though there is a mechanism such as the RFD regulation mentioned earlier to support access to forest genetic resources in reserved forests, such benefit-sharing has been not regulated so far. Although the Regulation of the National Committee on Biodiversity Conservation and Utilization on Criteria and Approaches of Access to Genetic Resources and Benefit Sharing from Their Use has provided detailed procedures and necessary documents to make MAT of benefit-sharing mechanisms, further investigation is needed in compliance with the Acts relevant to Forest, Reserve Forest, National Park, and Wildlife Preservation and Protection.

Under the Plant Variety Protection Act (2542) of the Ministry of Agriculture and Cooperatives, the benefit-sharing mechanisms of plant variety, including wild plants collected from natural habitats, were made. For use of wild plants and/or their genetic material in study or research activities for commercial purposes, there must be the MAT of benefit-sharing and its monetary incentives are contributed to the Plant Variety Protection Fund. Under the objectives of establishment of the Fund, income will be used for support and assistance in activities or missions relevant to conservation, and research and development of plant variety. In other cases, some organizations may possess forest genetic materials, collected from forest areas. Possession of those materials is for the main purpose of either research activities or commercialization. The main organizations in possession of these materials are Thailand Institute of Scientific and Technological Research (TISTR), National Center for Genetic Engineering and Biotechnology (BIOTEC), Botanical Garden Organization (BGO) and academic institutions/universities. Normally, some organizations developed and determined their own rules and regulations relevant to access and benefit-sharing of collected forest genetic materials in form of Material Transfer Agreement (MTA).

Chapter 8

The Contribution of Forest Genetic Resources to Food Security, Poverty Alleviation and Sustainable Development

Introduction

Generally, the history of mankind and civilizations is connected with forests and plants. Forests are important because of the goods and services they provide to people in various aspects. Forests are deeply rooted in people's social, cultural and spiritual spheres so it can be said that the livelihoods of most dependent people around the world are linked with forests and its health.

Forests cover approximately 30% of the global surface and provide ecological goods and services including food, medicines, fuel and other basic necessities to approximately 1.6 billion people across the world. As a consequence, forest resources have been heavily utilized to serve the growing demand of people who, in their daily lives depend upon products gathered from the forests. This situation has lead to the heavily deterioration of forest resources in most regions of the world. According to the FAO (2009), deforestation rates were estimated around 13 m ha per year with particularly 7.3 m ha per year during 2000-2005. Such heavy deforestation has seriously impacted the biodiversity of forest resources with approximately 8,000 tree species, or 9 per cent of the total number of tree species worldwide currently under threat of extinction (United Nations Forum on Forests [UNFF], 2010).

In Thailand, out of a total population of 65 million over 70% of the population resides in rural areas of the country. Some 1.2 to 2 million people are reported to live in and around protected areas, while 20 – 25 million people are living in and near national forest reserves. Most of those 20 plus million people use forest products for household consumption or for sale in markets for cash income (Wichawutipong, 2005). However, 46 per cent of these rural people are found to be in a high or medium level of poverty, and forest products are an important source of their livelihood. Poverty is then accounted as the most significant cause of deforestation and loss of biodiversity of the country (FAO, 2009).

In order to mitigate the problems of deforestation and loss of biodiversity, sustainable management and the fair, equitable sharing of the benefits derived from the use of forest products, biodiversity and genetic resources should be concerned. Moreover, appropriate access and adequate management for diversity and multiple benefits of genetic resources will not only sustainably maintain a healthy natural habitat for forest biodiversity, but will also increase the capacity for poverty reduction of those forest dependants through food security and economic enhancement. This chapter will discuss forest genetic resources in relation to economic, social and environmental aspects as well as their contribution to food security, poverty alleviation and sustainable development.

Forest biodiversity: a major pool of genetic resources to provide food security and poverty alleviation

According to Turner *et al.* (2012), the global potential for biodiversity conservation to support poor communities is considered rather high. The aggregate benefits are valued at three times the estimated opportunity costs and exceed $1 per person per day for 331 million of the world's poorest people. In the national scale, Thailand is species-rich in floral, faunal and cultural diversity, accounting for 7 per cent of the world's flora and fauna. There are approximately 15,000 plant species, 4,591 species of vertebrates and about 83,000 invertebrate species, of which 14,000 species can be identified. Some of those flora and fauna have been gathered and utilized by forest dependants since ancient times. Due to the implementation of a nation-wide logging concession ban in 1989, local dwellers are not allowed to fell or harvest any kind of living trees from natural forests for household or commercial consumption. However, local people are allowed to collect dry wood and other NWFPs for their subsistence needs. NWFPs such as mushrooms, rattan, bamboo and bamboo shoots, wild vegetables, flowers, fruits and nuts, and medicinal plants are mostly used for household consumption to supplement diets, but are also sold to local markets for cash income.

Due to the high economic potential of NWFPs, as they provide for the material needs, cash income and employment for local inhabitants, their significance to the rural [and up to national] economies should then be considered. They can alleviate or reduce rural poverty, as they offer the means to increase both the food production and incomes of the local poor (Martinez, 2004). Emphandhu and Kalyawongsa (2003) found high usage of NWFPs in term of harvested products from both flora and fauna of 200 villages living within protected areas of the Western Forest Complex (WEFCOM) of the country. However, according to the FAO (2009), 500 species of edible natural plants are traditionally used across the country In particular, 85 percent of them are consumed by households. Table 17 lists the potential uses of example trees and other woody species that are important in Thailand for food security and livelihoods.

In order to illustrate the significance of Non-Timber Forest Products (NTFPs) in responding to poverty alleviation, the potential of such plants as bamboo and rattan is listed as an example below:

Table 17 List of potential uses for food security and poverty reduction of example trees and other woody species that are important in Thailand

Species		Use for food security	Use for poverty reduction
Botanical name	**Native (N) or exotic (E)**		
Irvingia malayana Oliv. Ex A.W.Benn.	N	Edible nut	Seed can be sold as cosmetic ingredient
Aquilaria crassna Pirrre ex Lecomter	N		Incensed wood is used as fragrance wood and perfume oil
Dioscorea hispida Dennst.	N	Bulb can be used as major starch	
Senna siamea (Lam.) Irwin & Barneby	E	Young leaves can be eaten	Young leaves contain medicinal property
Sesbania grandiflora (L.) Desv.	E	Young leaves can be eaten	Young leaves contain medicinal property
Xylia xylocarpa (Roxb.) Taub.	N		Seed contains medicinal property
Cratoxylum formosum (Jack) Dyer	N	Young leaves can be eaten	Young leaves contain medicinal property
Sauropus androgynus (L.) Merr.	E	Young leaves can be eaten	
Dendrocalamus membranaceus Munro	N	Young shoot can be eaten	Stem can be sold as raw material for construction
Bambusa nana hort. ex Bean	E	Young shoot can be eaten	Stem can be sold as raw material for construction
Bambusa blumeana Schult.f.	N		Stem can be sold as raw material for construction
Dendrocalamus hamiltonii Nees & Arn. ex Munro	N	Young shoot can be eaten	Stem can be sold as raw material for construction
Bambusa sp.	N	Young shoot can be eaten	
Spondias pinnata (L.f.) Kurz	N	Fruit can be eaten	Bark can be used as natural dye
Diospyros mollis Griff.	N	Mature fruit use for dye	Seed contains medicinal property
Phyllanthus emblica L.	N	Minor fruit	Fruit contains medicinal property
Tamarindus indica Linn.	E	Fruit	Fruit contains medicinal property
Gluta usitata (Wall.) Ding Hu	N	Lacquer sap for Lacquer ware	Lacquer sap can be used in lacquerware industry
Parkia timoriana Merr.	N	Seed can be eaten	

Bamboo Approximately 60 species of bamboo were reported in Thailand covering 800,000 ha in 1998 with an average annual yield of 0.1 ton/ha green weight. The country's potential annual production of bamboo from natural sources is about 500,000 tons. Since bamboo shoots are edible, local villagers use them for their own consumption whereas bamboo poles are sold in the domestic market for wood used in construction. A major species of edible shoots is *Dendrocalamu asper* (Roem. & Fchult.) Backer ex Heyne which is extending rapidly. Estimated average bamboo production from 1980 to 1990 was 49.2 million culms or about 147,600 tons (FAO, 2009).

With its characteristic of fast growth, easy propagation, and short maturity period, bamboo is a suitable species for afforestation, for soil conservation and for community forestry programs. Compared to tree crops, bamboo can produce an economic return in a shorter period of time and can more easily be converted to value-added products. Developing bamboo cultivation and marketing channels will increase household income and livelihood of local dwellers and improve the rural economy.

Rattan Rattan is used by local people to produce various utensils for their own use. Cash income can also be obtained from rattan handicrafts. Rattan species were considered as non-reserved forest products and no permission was required for harvesting until a Royal Decree was enacted in 1987 which specified rattan as a reserved forest product. Rattan species are naturally distributed in Thailand belonging to the genus *Calamus*, *Daemorops*, *Korthalsia*, *Plectocomia*, *Plectocomiopsis*, *Myrialepis.* As a consequence, Thailand has banned the harvesting of rattan in natural forests and its export in raw form. However, harvesting for food from local forest dependants is still allowed, while growing rattan on private lands has also become popular. Rattan gardens increase food security and as traded goods enhance household income. Edible rattan shoots can be harvested in 1-1.5 years from planting, while full production is achieved at 6 years. Shoot production can last more than 20 years. It is estimated that a shoot can yield up to 1,562 tones/ha (FAO, 2009).

In addition to the direct benefits from such products, indirect benefits will also be derived from the genetic resource pool. Activities like ecotourism, which has become more popular among nature-lovers, can be counted in this case, since ecotourism involves travelling to natural areas for nature study as well as admiring the beauty of scenic areas. Ecotourism has the additional benefit of improving the welfare of local inhabitants (Changtragoon, 2003b). In particular, tourism in Thailand is well-developed and diverse, representing a huge market potential for nature-based tourism in the country. The government's policy on tourism for the past few years has been geared more towards sustainable tourism development with emphasis on community participation, safety and non-exploitation. One of the fastest-growing sectors of the tourism industry is ecotourism, whereby tourists visit undisturbed natural areas to experience spectacular scenery and to view wildlife. The presence of local people can add value to the ecotourism experience through the inclusion of cultural aspects.

Policy and legal frameworks to support sustainable management of biodiversity and genetic resources

Over the last four decades of national development, Thailand has had to continuously adjust to changing socio-economic situations. According to the FAO (2009), the First and Second NESDP (1961-1971) emphasized economic growth through investment in infrastructure for civilization. Until the Eighth Plan (1997-2001), participation from all levels of society was addressed in order to create a balance in the development of the economy, society and environment, while the Ninth Plan (2002-2006) stated the Sufficiency Economy philosophy to guide the development and administration of the country. Development goals were to balance the development of the country by respecting people, society, economy and the environment in order to achieve sustainable development and the well-being of the Thai people. In this regard, public awareness of natural resources through formal education and information campaigns was developed. The Tenth Plan (2007-2011) aimed to keep ecological balance as well as to maximize the social benefits and environmental protection. Up to the present, the upcoming Eleventh plan (2012-2016) promises to maintain the environment in good condition and adopt environment-friendly production systems to achieve sustainability.

Regarding legal framework, The Government of Thailand has established stringent laws for the protection, use and conservation of forest areas as well as biodiversity. Presently, there are two main Forestry Acts that support those conceptual ideas:

1. Forest Act, B.E. 2484 (1941) concerns logging operations and non-wood forest product (NWFP) collection.
2. National Forest Reserve Act, B.E. 2507 (1964) includes the determination of the National Reserved Forest and the control and maintenance of the National Reserved Forest.

The contribution of forest genetic resources to food security and poverty alleviation in the regional context

At the Association of Southeast Asian Nation - Food and Agriculture Organization (ASEAN-FAO) Regional Conference on Food Security held in Bangkok during 27-28 May 2009, food security and sustainable development of agriculture and forestry, as well as mitigation of climate change of the region were addressed within the conference. As a consequence, the ASEAN Secretariat then developed an inclusive participatory mechanism to achieve the proposed concept called "Multi-Sectoral Framework on Climate Change and Food Security". This framework intends to "*identify and address emerging issues related to food security and emerging issues related to Food Security of the ASEAN Integrated Food Security Framework (AIFS) and Strategic Plan of Action on Food Security*" which were adopted by the ASEAN Summit in March 2009. In this regard, relevant government agencies will be responsible for preparing a detailed action plan at the national level to ensure the achievement of food security and poverty alleviation.

An alternative approach for genetic resource management to contribute food security and poverty alleviation: community forestry programs in the national context

Community forestry programs have been well accepted worldwide as a "pro poor" strategy for promoting sustainable forest management. The programs propose many activities such as agro-forestry to secure food while helping to alleviate poverty across the world. So far, about 11,400 villages (or 15.5 per cent of all the villages) have been involved in managing community forests in Thailand, of which approximately 8,331 villages are reported to have formally registered their community forest with the RFD. These community forests are reported to cover an area of 196,667 ha in national forest reserves (112,869 ha) and other forest areas (83,798 ha), accounting for about 1.2 percent of the total forest area (Community Forest Management Bureau, 2010) of Thailand. Particularly, 72 per cent of existing community forests is concentrated in the Northeast and North regions where the majority of the poor live.

Generally, many community forests across the country are found to be rich in biodiversity as a genetic resource pool. This richness is beneficial in terms of biodiversity conservation, as well as for forest resource utilization. Local dwellers are allowed to use community forests to collect dead wood for subsistence needs while NWFPs such as mushrooms, rattan, bamboo and bamboo shoots, wild vegetables, flowers, fruit and nuts, and medical plants are also allowed to be collected. Those selected species will not only provide multiple benefits as a "natural supermarket" to ensure food security to the community, but will also provide genetic resource conservation. Furthermore, collected species are used mostly for household consumption especially during the time of food shortage and for supply to local markets for cash income. The types of NWFPs collected from community forests vary from place to place, and their volumes can be locally highly significant. For example, in 2004, Wichawuthipong (2005) found that villagers collected about 13 tons of NWFPs from a Dry Dipterocarp Forest covering 287 ha in Nong Song Hong and Dong Keng community forests in Khon Kaen Province. Although few households were reported to be engaged in the marketing of NWFPs, cash generated through forest product trade in local markets was expected to be high. For example, in Dong Keng in 2004, NWFPs sold in the local market accounted for 5.25 per cent of the average annual household income. According to the Thailand Environment Monitor Series in 2004 (as cited in FAO, 2009), a village generates, on average over US$ 25,000 per year by selling NWFPs. Thus, with 73,467 villages in the country, this would amount to approximately US$2 billion per annum from the NWFP trade in the local market alone.

Future challenge for alleviating poverty and supporting sustainable forest management

Problem solving for the loss of local genetic resources and biodiversity should be based on the consideration of inviting local communities living nearby their natural resources to participate in management and conservation plans. A combination of local and scientific knowledge could create a pathway that would be in harmony with the natural environment and would lead to sustainable development. This combination holds the potential to raise the quality of life of local dwellers that depend upon the natural resources for their livelihood. The Thai Forestry Master Plan of 1992 recognized community forestry as one of the main strategies to achieve sustainable forest management (RFD, 1993). The following set of keybuilding blocks for effective community forestry development are necessary in order to create sustainable genetic resource conservation.

Community forestry policy and strategy There is a need to recognize the key role of knowledge of forests and forest products by the local people, as well as their successful efforts in managing and regenerating forests and trees in their villages. Communities must encourage permanent training, technical assistance and transfer of technical know-how within and between communities. Furthermore, NTFPs are a main component of the rural economy and on which many livelihoods rely for subsistence so that their marketing and their role in livelihood development and poverty reduction should be emphasized within the national level of policy and strategy.

Benefits and costs of community forestry Benefits are perceived as a key to attract local people for active participation in community forestry activities. Community forestry should consider the production of goods and services beyond subsistence needs, i.e. development of commercial operations including collection and sales of NWFPs. This would help to raise the income of poor households while adding value to forests for society at large.

Tenure and use rights of forest and forest products "Sense of ownership" and "secured use rights" of forest and forest products are other important factors for motivating community forestry programs. This concept places a stress on "authorities" and "responsibilities" of the community for the protection and management of community forests. Effective community forestry programs should be concerned with these functions and include them within the capacity building program.

Organizing communities and forest-based community enterprises Community members need to organize themselves to be able to manage the forest and to ensure that different forest goods and services are available in a sustainable and equitable manner. Communities can generate revenue to reduce poverty while contributing to the attainment of broader societal needs of forest goods and services.

Both domestic and international markets for NWFPs have expanded dramatically and as a new opportunity for payment schemes for environmental services. Local people are already extensively involved in collecting NWFPs within and outside community forests and trading them in local markets. It is necessary to link community forest groups with these various initiatives through training, communication and eventual adjustment of financing instruments.

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Annexes

Annex 1 The main forest tree species considered as threatened in Thailand

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
1	*Acer chiangdaoense* Santisuk	Kuam chiang dao	-
2	*Acer laurinum* Hassk.	Kuam khao	-
3	*Acer thomsonii* Miq.	Kuam bai yai	-
4	*Acer wilsonii* Rehder	Kuam phu kha	-
5	*Aegialitis rotundifolia* Roxb.	Bai pai	-
6	*Aesculus assamica* Griff.	Ma naing nam	-
7	*Ailanthus triphysa* (Dennst.) Alston	Ma yom pa	-
8	*Albizia attopeuensis* (Pierre)I.C.Nielsen	-	-
9	*Albizia splendens* Corner	-	-
10	*Albizia vialeana* Pierre	-	-
11	*Alphonsea boniana* Finet & Gagnep.	Tam yao phon tum	-
12	*Alphonsea cylindrica* King	Tam yao lek	-
13	*Alphonsea javanica* Scheff.	Tam yao khaek	-
14	*Alphonsea siamensis* P.J.A Kessler	-	-
15	*Alstonia angustiloba* Miq.	Tin pet khao	-
16	*Altingia excelsa* Noronha	Satue	-
17	*Amoora cucullata* Roxb.	Daeng nam	-
18	*Anaxagorea javanica* Blume	Champun	-
19	*Anisoptera laevis* Ridl.	Krabak daeng	EN
20	*Anisoptera scaphula* (Roxb.) Kurz	Cha muang	CR
21	*Anisoptera curtisii* Dyer ex King	Krabak thong	CR
22	*Antidesma faponicum*	Mao kraeng	-
23	*Antidesma forbesii* Pax & K.Hoffm.	Mamoa fop	-
24	*Antidesma laurifolium* Airy Shaw	Mamao khao	-
25	*Antidesma leucopodon* Miq.	Mao polo	-
26	*Antidesma orthogyne* (Hook.f.) Airy shaw	-	-
27	*Antidesma pendulum* Hook.f.	-	-
28	*Aporosa arborea* (Blume) M?ll.Arg.	Plueak khao	-
29	*Aporosa duthieana* King ex Pax & K.Hoffm.	Mueat dut	-
30	*Aporosa falcifera* Hook.	Nam phueng	-
31	*Aporosa globifera* Hook.f.	Mueat klom	-
32	*Aporosa nervosa* Hook.f.	Mueat khaeng	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
33	*Aporosa penangensis* Ridl.) Airy Shaw	Takhop nok	-
34	*Aporosa stellifera* Hook.f.	Mueat kliang	-
35	*Aporosa symplocoides* Hook.f. Gage	Mueat khlai	-
36	*Aquilaria crassna* Pierre ex Lecomte	Kritsana	-
37	*Aquilaria hirta* Ridl.	Cha nae	-
38	*Aquilaria malaccensis* Lam.	Mai hom	-
39	*Archidendron bubalinum* (Jack) I.C.Nielsen	Niang nok	-
40	*Archidendron conspicum* (Craib) I.C.Nielsen	Chaom ton	-
41	*Archidendron contortum* (C.Mart.)I.C.Nielsen	-	-
42	*Archidendron ellipticum* (Blume) I.C.Nielsen	Klet chara khe	-
43	*Archidendron glomeriflorum* (Kurz) I.C.Nielsen	Ya po	-
44	*Archidendron quocense* (Pierre) I.C.Nielsen	Yong	-
45	*Baccaurea bracteata* Müll.Arg.	Ramai pa	-
46	*Baccaurea brevipes* Hook.f.	Mayom pa	-
47	*Baccaurea lanceolata* (Miq.) Müll.Arg.	Som lok	-
48	*Baccaurea macrocarpa* (Miq.) Müll.Arg.	Lang khae	-
49	*Baccaurea macrophylla* (Müll.Arg.) MÜll.Arg.	Lang khae	-
50	*Baccaurea minor* Hook.f.	Champu ning	-
51	*Baccaurea motleyana* (Müll.Arg.) MÜll.Arg.	Mafai farang	-
52	*Baccaurea polyneura* Hook.f.	Mafai ling	-
53	*Baccaurea ptychopyxis* Airy Shaw	Somfai din	-
54	*Baccaurea racemosa* (Reinw.ex Blume) Müll.Arg.	-	-
55	*Baccaurea sumatrana* (Miq.) Müll.Arg.	-	-
56	*Blumeodendron kurzii* (Hook.f.) Sm.	Khun thaen	-
57	*Blumeodendron tokbrai* (Blume)J.J.Sm.	Ka ya	-
58	*Brachylophon curtisii* Oliv	-	-
59	*Brachytome scortechinii* King & Gamble	-	-
60	*Bretschneidera sinensis* Hemsl.	Chomphu phu kha	-
61	*Brownlowia tersa* (L.) Kosterm.	Nam nong	
62	*Bruguiera hainesii* C.G.Rogers	Thua khao	-
63	*Canarium denticulatum* Blume	Laen ban	-
64	*Canarium euphyllum* Kurz	Mang	-
65	*Canarium littorale* Blume	Lueam khao	-
66	*Canarium parvum* Leenh.	Samo pha	-
67	*Canarium pilosum* Benn.	Samo khon	-
68	*Canarium pseudodecumanum* Hochr.	Han	-
69	*Canarium pseudosumatranum* Hochr.	Ka la	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
70	*Canarium strictum* Roxb.	Mong	-
71	*Canarium sumatranum* Boerl. & Koord.	Buk yuak	-
72	*Canurium patentinervium* Miq.	Phuam phrao	-
73	*Ceriscoides campanulata* (Roxb.)Tirveng.	Phut nam	-
74	*Ceriscoides kerrii* Azmi	-	-
75	*Ceriscoides mamillata* (Craib) Tirveng.	-	-
76	*Chondrostylis kunstleri* (King ex Hook.f.) Thwaites	Tong khaeng	-
77	*Claoxylon oliganthum* Airy Shaw	Phak wan pangnga	-
78	*Claoxylon putii* Airy Shaw	Phak wan pang tong	-
79	*Cleidiocarpon laurinum* Airy Shaw	-	-
80	*Cleidocarpon brevipetiolatum* Pax & K. Hoffm.	-	-
81	*Cleistanthus decurrens* Hook.f.	Nok non kan krip	-
82	*Cleistanthus glandulosus* Jabl.	-	-
83	*Cleistanthus hirsutipetalus* Gage	Nok non dok khon	-
84	*Cleistanthus macrophyllus* Hook.f.	Nok non bai yai	-
85	*Cleistanthus papyraceus* Airy Shaw	Khaen khae	-
86	*Cleistanthus praetermissus* Gage	Nok dam	-
87	*Cleistanthus rufus* (Hook.f.) Gehrm.	Nok non bai daeng	-
88	*Clerodendrum smitinandii* Ridl.	Nom sawan ton	-
89	*Cordia subcordata* Lam.	Man thale	-
90	*Cotylelobium lanceolatum* Craib	Khaim	VU
91	*Croton acutifolius* Esser	Plao phae	-
92	*Croton argyratus* Blume	Plao ngern	-
93	*Croton hutchinsonianus* Hosseus	Phao phae	-
94	*Croton kerrii* Airy Shaw	-	-
95	*Croton kongkandanus* Gagnep.	-	-
96	*Croton poomae* Esser	-	-
97	*Croton sepalinus* Airy Shaw	Plao ngern	-
98	*Crudia caudata* Prain	Mu phom	-
99	*Crudia gracilis* Prain	Phang kha	-
100	*Crudia lanceolata* Ridl.	Lao khang	-
101	*Crudia speciosa* Prain	-	-
102	*Cyathocalyx martabanicus* Hook.f. & Thomson var.*harmandii* Finet & Gagnep.	Nang leo	-
103	*Cyathocalyx sumatranus* Scheff.	Kradang nga dong	-
104	*Cynometra craibii* Gagnep.	Hae	-
105	*Dacryodes costata* (Benn.) H.J.Lam	Ma lueam	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
106	*Dacryodes kingii* (Engl.) Kalkman	Kok daeng	-
107	*Dacryodes rostrata*(Blume) H.J.Lam	Kok khao	-
108	*Dalbergia cochinchinensis* Pierre	Pha yung	-
109	*Dillenia excelsa* (Jack.) Gilg	San dam	-
110	*Dillenia grandifolia* Wall. ex Hook.f. & Thomson	San bai yai	-
111	*Dillenia scabrella(D.Don)Roxb. Ex Wall.*	San	-
112	*Dimorphocalyx muricatus* (Hook.f.)Airy shaw	-	-
113	*Diospyros andamanica* (Kurz) Bakh. var. *aequabilis* Bakh.	Plap anda	-
114	*Diospyros apiculata* Hiern	Ma plap khai nok	-
115	*Diospyros bambuseti* Fletcher	Ma kluea aran	-
116	*Diospyros borneensis* Hiern	Khi nu	-
117	*Diospyros cauliflora* Blume	Thao saen pom	-
118	*Diospyros coaetanea* (Craib) Fletcher	Lam ta khwai	-
119	*Diospyros collinsae* Craib	Plap yot dam	-
120	*Diospyros confertiflora* (Hiern) Bakh.	Luk hua nok	-
121	*Diospyros dictyoneura* Hiern	Nang ko	-
122	*Diospyros diepenhorstii* Miq.	Nian	-
123	*Diospyros dumetorum* W.W.Sm.	Ma kluea noi	-
124	*Diospyros filipendula* Pierre ex Lecomte	Lambit dong	-
125	*Diospyros fulvopilosa* Fletcher	Nian	-
126	*Diospyros gracilis* Fletcher	Ma kluea ka	-
127	*Diospyros insidiosa* Bakh.	Chan khao	-
128	*Diospyros kerrii* Craib	Ma plap dong	-
129	*Diospyros kurzii* Hiern	Plap man	-
130	*Diospyros latisepala* Ridl.	Thep phanom	-
131	*Diospyros longepilosa* Phengklai	Ma phlap khon	-
132	*Diospyros pendula* Hasselt ex Hassk.	In pa	-
133	*Diospyros pubicalyx* Bakh.	Dam dong	-
134	*Diospyros scalariformis* Fletcher	Phlap tong khao	-
135	*Diospyros scortechinii* King & Gamble	Khai nok	-
136	*Diospyros thaiensis* Phengklai	Ma plap lep nang	-
137	*Diospyros toposia* Buch.-Ham.var. *toposioides* (King & Gamble) Phengklai	Mao lek	-
138	*Diospyros transitoria* Bakh.	Ma plap thong	-
139	*Diospyros trianthos* Phengklai	Sam kloe	-
140	*Diospyros truncata* Zoll. ex Moritzi	Plap noi	-
141	*Diospyros winitii* Fletcher	Ma plap chao khun	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
142	*Diptercarpus gracillis* Blume	Yang sian	CR
143	*Diptercarpus hasseltii* Blume	Yang tai	CR
144	*Diptercarpus retusus* Blume	Yang khuan	VU
145	*Dipterocarpus acutangulus* Vesque	Yang bu ke	-
146	*Dipterocarpus baudii* Korth.	Yang khon	CR
147	*Dipterocarpus chartaceus* Symington	Yang wat	CR
148	*Dipterocarpus dyeri* Pierre	Yang klong	CR
149	*Disepalum pulchrum* (King) j. Sinclair	-	-
150	*Distylium annamicum* (Gagnep.)Airy shaw	Khai nok katha dong	-
151	*Distylium indicum* Benth.ex C.B. Clarke	Khai nok katha	-
152	*Dolichandrone columnaris* Santisuk	Khae thung	-
153	*Drypetes assamica* Drypetes assamica (Hook.f.) Pax & K.Hoffm.	Mak khon	-
154	*Drypetes cambodica* Gagnep.	Mak kha mae	-
155	*Drypetes curtisii* (Hook.f.) Pax & K.Hoffm.	Luk na kha	-
156	*Drypetes dasycarpa* (Airy Shaw) Phuph. & Chayamarit	Mak in	-
157	*Drypetes harmandii* Pierre ex Gagnep.	Kluean	-
158	*Drypetes helferi* (Hook.f.) Pax & K.Hoffm.	Pra kham khao luang	-
159	*Drypetes ochrothrix* Airy Shaw	Luk it	-
160	*Drypetes pendula* Ridl.	Pra kham yai	-
161	*Drypetes subsessilis* (Kurz) Pax & K.Hoffm.	Mak khan san	-
162	*Drypetes viridis* Airy Shaw	Mak muang waeng	-
163	*Durio graveolens* Becc	Thu rian rak kha	-
164	*Durio griffithii* (Mast.) Bakh.	Thu rian nok	-
165	*Durio lowianus* Scort. ex King	Cha rian	-
166	*Durio macrophyllus* Ridl.	-	-
167	*Durio mansoni* (Gamble) Bakh.	Thu rian pa	-
168	*Dyera costulata* (Miq.) Hook.f.	Tin pet daeng	-
169	*Endospermum peltatum* Merr.	Phu rat khuan	-
170	*Enicosanthum membranifolium* J.Sinclair	Nang na dok yai	-
171	*Enkleia thorelii* (Lecomte) Nevling	Pradu khok	-
172	*Enrismanthus obliquus*	Aet	-
173	*Erythrophleum succirubrum* Gagnep.	Sat	-
174	*Excoecaria bantamensis* MÜll.Arg.	Tatum pa	-
175	*Fagraea crenulata* Maingay ex C.B.Clarke	Hu chang	-
176	*Fernandoa collignonii* (D.Dop) Steenis	Khae hang khang san	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
177	*Firmiana kerrii* (Craib) Kosterm.	Po tab	-
178	*Fosbergia thailandica* Tirveng. & Sastre	Khat khao phu kha	-
179	*Gardenia carinata* Wall.	Rak na	-
180	*Gardenia thailandica* Tirveng.	Phut pa	-
181	*Gardenia truncata* Craib	-	-
182	*Gardeniopsis longifolia* Miq.	-	-
183	*Garuga floribunda* Decne.	Takhram hin	-
184	*Glochidion oblatum* Hook.f.	Khrai taek	-
185	*Glochidion perakenses* Hook.f.	Chumset	-
186	*Glochidion santisukii* Airy shaw	Khrai yai	-
187	*Gmelina racemosa* (Lour.)Merr.	So hin	-
188	*Goniothalamus cheliensis* Hu	-	-
189	*Goniothalamus giganteus* Hook.f. & Thomson	Pannan chang	-
190	*Goniothalamus laoticus* (Finet & Gagnep.) Bân	Khao lam dong	-
191	*Gymnocladus burmanicus* C.E parkinson		-
192	*Gyrinops vidalii* P.H.Hŏ	Kritsana	-
193	*Heritiera formes* Buch.-Ham.	Ngon kai bai lek	-
194	*Heritiera macrophylla* Wall. ex Kurz	Ngon kai fa	-
195	*Heritiera parvifolia* Merr.	Ngon kai pa	-
196	*Heritiera simplicifolia* (Mast.) Kosterm.	Chum phraek khao	-
197	*Hernandia nymphaeifolia* (C.Presl) Kubitzki	Pho kring	-
198	*Heterophragma sulfureum* Kurz	Khae rokfa	-
199	*Hopea beccariana* Burck	Ta khian khao	CR
200	*Hopea griffithii* Kurz	Ta khian rak	VU
201	*Hopea helferi* (Dyer) Brandis	Krabok krang	CR
202	*Hopea latifolia* Symington	Khian rak	CR
203	*Hopea oblongifolia* Dyer	Mo ran	DD
204	*Hopea pedicellata* (Brandis) Symington	Saya dam	EN
205	*Hopea recopei* Pierre ex Laness.	Chan phu	EN
206	*Hopea sangal* Korth.	Ta khian khon	CR
207	*Hopea siamensis* F. Heim	Ta khian khao	CR
208	*Hopea sublanceolata* Symington	Ta khian	CR
209	*Hopea thorelii* Pierre	Ta khian bi yai	CR
210	*Hunteria zeylanica* (Retz.) Gardner ex Thwaites	Muk khao	-
211	*Ilex umbellulata* Loes.	Nao nai	-
212	*Kibatalia arborea* (Blume) G.Don	Ba du bu wae	-
213	*Kopsia angustipetala* Kerr	Phut pakpet	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
214	*Kopsia arborea* Blume	Phut dong	-
215	*Leucosceptrum canum* Sm.	Kaphrao ton	-
216	*Loropetalum chinense* (R.Br.) Oliver	Khai nok khao	-
217	*Mallotus calocarpus* Airy shaw	-	-
218	*Mallotus garrettii* Airy shaw	-	-
219	*Mallotus kingii* Hook.f.	-	-
220	*Mallotus kongkandae* Welzen & Phattarahirankanok	-	-
221	*Mallotus leucodermis* Hook.f.	Ka dong dong	-
222	*Mallotus miquelianus* (scheff.) Boerl.	-	-
223	*Mallotus montanus* (MÜll. Arg.)Airy shaw	-	-
224	*Mallotus penangensis* MÜll. Arg.	-	-
225	*Mallotus plicatus* (MÜll. Arg.)Airy shaw	-	-
226	*Mallotus stipularis* Airy Shaw	Nut	-
227	*Mallotus subcuneatus* (Gage) Airy shaw	-	-
228	*Mallotus tiliifolius* (Blume) MÜll. Arg.	-	-
229	*Mallotus viridis* Welzen & Chayamarit	Ma soi	-
230	*Manilkara kauki* (L.) Dubard	Lamut thai	-
231	*Marsypopetalum pallidum* (Blume) Kurz	Nommaeo noi	-
232	*Mezzettia parviflora* Becc.	Hua tao	-
233	*Miliusa mollis* Pierre var. sparsior Craib	Ching chap	-
234	*Mitrephora alba Ridl.*	Phrom khao	-
235	*Mitrephora keithii* Ridl.	Maha phrom	-
236	*Mitrephora tomentosa* Hook.f. & Thomson	Dong dam khao	-
237	*Mitrephora wangii* Craib	Lamduan doi	-
238	*Mitrephora winitii* Craib	Maha phrom	-
239	*Monocarpia marginalis* (Scheff.) J.Sinclair	Ma faet	-
240	*Neesia altissima* (Blume) Blume	Thu rian phi	-
241	*Neesia malayana* Bakh.	Chang hai	-
242	*Neobalanocarpus heimii* (King) P.S.Ashton	Ta khian chan ta maeo	VU
243	*Orophea kerrii* P.J.A Kessler	Phrik nok mo kha	-
244	*Ostodes paniculata* Blume var. paniculata	Ma khang dong	-
245	*Parashorea densiflora* slooten & Symington	Khaen hin	-
246	*Parkia leiophylla* Kurz	San phak la	-
247	*Parkia sumatrana* Miq. subsp. *streptocarpa* (Hance) H.C.F. Hopkins	Luk ding	-
248	*Pauldopia ghorta* (G.Don) Steenis	Rakhang thong	-
249	*Pertusadina malaccensis* Ridsdale	Phan ru	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
250	*Phyllanthus mirabilis* MÜll. Arg.	Khi lek ruesi	-
251	*Phyllanthus polyphyllus* Willd. var. *siamensis* Airy Shaw	Siao yai	-
252	*Pitardella cf. poilanei* Triveng.	-	-
253	*Pithecellobium tenue* Craib	Kamlang chang san	-
254	*Platymitra macrocarpa* Boerl.	Ham chang	-
255	*Polyalthia stenopetala* (Hook.f. & Thomson) Ridl.	Nuat pladuk	-
256	*Polyalthia cauliflora* Hook.f.& Tomson var. *wrayi* (Hemhl.) J.Sinclair	-	-
257	*Polyalthia clavigera* King	-	-
258	*Polyalthia lateritia* J.Sinclair	-	-
259	*Porterandia anisophylla* (Jack ex Roxb.) Ridl.	-	-
260	*Porterandia mussaendoides* (Craib)Tirveng.	-	-
261	*Porterandia scortechinii* (King & gamble)Ridl	Hu kwang lek	-
262	*Pseuduvaria multiovulata* (C.E.C fisch.) J.Sinclair	Sang yu dok yai	-
263	*Pseuduvaria setosa* (King) J.Sinclair	Sang yu bai lek	-
264	*Pterocymbium laoticum* Tardieu	-	-
265	*Pterospermum grande* Craib	Sam tao	-
266	*Pterospermum grandiflorum* Craib	Sa tao	-
267	*Ptychoryxis plagiocarpa* Airy Shaw	-	-
268	*Radermachera boniana* Dop	-	-
269	*Radermachera eberhardtii* Dop	-	-
270	*Radermachera hainanensis* Merr.	Pip thong	-
271	*Radermachera peninsularis* Merr.	Khae than bok	-
272	*Radermachera pinnata* (Blanco) Seem. subsp. *acuminata* (Steenis) Steenis	Peka phru	-
273	*Rauvolfia sumatrana* Jack	Tin pet lek	-
274	*Reevesia pubescens* Mast. var. *pubescens*	Moli khon	-
275	*Reevesia pubescens* Mast. var. *siamensis* (Craib) Anthony	Moli siam	-
276	*Rhododendron ludwigianum* Hoss.	Kulap khao	-
277	*Rhododendron lyi* H.L.OEv.	Dok sam si	-
278	*Rhododendron simsii* Planch.	Kulap daeng	-
279	*Rhodoleia championii* Hook.f.	-	-
280	*Rothmannia sootepensis* (Craib) Bremek.	-	-
281	*Sageraea elliptica* (A.DC.) Hook.f. & Thomson	Kamok khao	-
282	*Santiria laevigata* Blume	Kap oi	-
283	*Santiria rubiginosa* Blume	Kok lek	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
284	*Santiria tomentosa* Blume	Ngon kai	-
285	*Santisukia kerrii* (Barnett & Sandwith) Brummitt	Khae santisuk	-
286	*Santisukia pagetii* (Craib) Brummitt	Kanchanika	-
287	*Saraca thaipingensis* Cantley ex Prain	Sok lueang,sri ya la	-
288	*Sauropus thyrsiflorus* Welzen	-	-
289	*Scaphium linearicarpum* (Mast.) Pierre	Thai phao khao	-
290	*Shorea assamica* Dyer ssp. *globifera* (Ridl.) Symington	Saya khao	CR
291	*Shorea bracteolate* Dyer	Saya nuan	EN
292	*Shorea curtisii* Dyer ex King	Saya lueang	-
293	*Shorea dasyphylla* Foxw.	Saya hin	EN
294	*Shorea faguetiana* F.Heim	Ka lo	EN
295	*Shorea farinose* C.E.C.Fisch.	Krabak dam	CR
296	*Shorea glauca* King	Aek	EN
297	*Shorea gratissima* (Wall. ex Kurz) Dyer	Khian sai	EN
298	*Shorea guiso* (Blanco) Blume	Teng tani	CR
299	*Shorea hypochra* Hance	Phanong	CR
300	*Shorea laevis* Ridl.	Teng kuan	-
301	*Shorea longisperma* Roxb.	Ka lo dam	-
302	*Shorea macroptera* Dyer	Chan hoi	-
303	*Shorea parvifloia* Dyer subsp. *Velutinata*	Saya khao	-
304	*Shorea parvifolia* Dyer subsp. *Parvifolia* P.S. Ashton	Saya lueang	-
305	*Shorea singkawang* (Miq.) Miq.	Mak on	CR
306	*Shorea sumatrana* (Slooten ex Thorenaar) Symington ex Desch	Palosali	CR
307	*Shorea thorelii* Pierre ex Laness.	Takhian teng	CR
308	*Sindora coriacea* (Baker) Prain	Kling	-
309	*Sindora siamensis* Teijsm. & Miq. var. *maritima* (Pierre) K. & S.S.Larsen	Ma kha tae	-
310	*Spathiostemon moniliformis* Airy Shaw	Khan laen	-
311	*Stelechocarpus cauliflorus* (Scheff.) R.E.Fr.	Ngam ngo	-
312	*Sterculia cordata* Blume	Po khon	-
313	*Sterculia gilva* Miq.	Po thong khao	-
314	*Sterculia hypochra* Pierre	Po fai	-
315	*Sterculia macrophylla* Vent.	Klet raet	-
316	*Sterculia urena* Roxb. var. *thorelii* (Pierre) Phengklai	Po tan	-
317	*Sterculia urena* Roxb. var. *urena*	Po khao	-

No.	Botanical Name	Thai Name	IUCN Red List Categories.*
318	*Stereospermum neuranthum* Kurz	Khaefoi	-
319	*Styrax rugosus* Kurz	En a khao	-
320	*Sycopsis dunnii* Hemsl.	Khai nok khum	-
321	*Symingtonea populnea* (R.Br.ex Griff.) Steenis	Pho sam hang	-
322	*Tabernaemontana corymbosa* Wall.	Sang la	-
323	*Tabernaemontana macrocarpa* Jack	Phut tai	-
324	*Teijsmanniodendron* coriaceum (C.B clarke)Kosterm.	Ka la	-
325	*Timonius corneri* K.M.Wong var. *penangianus* (Ridl.)K.M. Wong	-	-
326	*Trigonostemon kerrii* Craib	Thanong khop chak	-
327	*Trigonostemon thyrsoideus* Stapf	Lot thanong lueang	-
328	*Trivalvaria macrophylla* (Blume)Miq.	-	-
329	*Vatica diospyroides* Symington	Chan ka pho	CR
330	*Vatica mangachapoi* Blanco ssp. *Obtusifolia* (Elmer) Ashon	Sak pha	-
331	*Vatica pauciflora* (Korth.) Blume	Sak nam	EN
332	*Vatica philastreana* Pierre	Tha lok	DD
333	*Vatica stapfiana* (King) Slooten	Khanan	EN
334	*Vatica umbonata* (Hook.f.) Burck	Rue so	-
335	*Vatica bella* Slooten	Sak pik	CR
336	*Vidalasia murina* (Craib) Tirveng.	-	-
337	*Vidalasia pubescens* (Tirveng.& Sastre) Tirveng.	-	-
338	*Vitex cochinchinensis* Dop	Mak sa khang	-
339	*Wrightia coccinea* (Roxb.) Sims	Muk khon	-
340	*Wrightia lanceolata* Kerr	Mok khao	-
341	*Wrightia sirikitiae* D.J.Middleton & T.Suntisuk	Mok rachini	-
342	*Wrightia viridiflora* Kerr	Mok lueang	-
343	*Xylocarpus rumphii* (Kostel.) Mabb.	Taban	-

Remark * IUCN Red List Categories & Criteria : ver 2.3 (1994)

Annex 2 List of invasive alien species in Kankrachan Forest complex

No.	Botanical Name	Habit
1	*Arachis pintoi* Krap & Greg.	Creeping Herb
2	*Acacia farnesciana* (L.) Willd.	Shrub
3	*Acmella oleracea* (L.) R. K. Jansen	Herb
4	*Aeschynomene americana* L.	Shrub
5	*Ageratum conyzoides* L.	Herb
6	*Alternanthera dentata* (Moench) Scheygr	Herb
7	*Alternanthera pungens* Kunth	Herb
8	*Alternanthera sessilis* (L.) DC.	Herb
9	*Amaranthus spinosus* L.	Herb
10	*Amaranthus viridis* L.	Herb
11	*Annona squamosa* L.	Shrub
12	*Antigonon leptopus* Hook. & Arn.	Climber
13	*Asystasia gangetica* (L.) T. Anderson 'Chinese Violet'	Herb
14	*Asystasia gangetica* (L.) T. Anderson ssp. *micrantha* (Nees) Ensumu	Herb
15	*Axonopus compressus* (Sw.) Beauv.	Grass
16	*Basella rubra* L.	Herbaceous Climber
17	*Bidens pilosa* L.	Herb
18	*Brachiaria mutica* (Forssk.) Stapf	Grass
19	*Calotropis gigantea* (L.) W.T. Aiton	Shrub
20	*Canna indica* L.	Aquatic Herb
21	*Capsicum annuum* L. var. *acuminatum* Fingerh.	Herb
22	*Capsicum frutescens* L. var. *frutescens*	Herb
23	*Catharanthus roseus* (L.) G. Don	Herb
24	*Celosia aegentea* L.	Herb
25	*Centratherum punctatum* Cass.	Herb
26	*Centrosema pubescens* Benth.	Herbaceous Climber
27	*Chloris barbata* Sw.	Grass
28	*Chromoleana odoratum* (L.)R.M. King & H. Rob.	Herb
29	*Cleome rutidosperma* DC.	Herb
30	*Cleome viscosa* L.	Herb
31	*Conyza sumatrensis* (Retz.) Walker	Herb
32	*Cosmos sulphureus* Cav.	Herb
33	*Crassocephalum crepidioides* (Benth.) S. Moore	Herb
34	*Cynodon dactylon* (L.) Pers.	Grass
35	*Cyperus involucratus* Rottb.	Aquatic Herb
36	*Desmanthus virgatus* Willd.	Shrub
37	*Echinodorus cordifolius* (L.) Griseb.	Aquatic Herb
38	*Eichhornia crassipes* (C.Mart.) Solms	Aquatic Herb

No.	Botanical Name	Habit
39	*Eryngium foetidum* L.	Herb
40	*Euphorbia cyathophora* Murr.	Herb
41	*Euphorbia heterophylla* L.	Herb
42	*Euphorbia hirta* L.	Herb
43	*Euphorbia thymifolia* L.	Herb
44	*Evolvulus nummularius* (L.) L.	Creeping Herb
45	*Ficus religiosa* L.	Tree
46	*Gomphrena celosioides* Mart.	Herb
47	*Hedyotis corymbosa* (L.) Lam.	Herb
48	*Hydrocotyle umbellata* L.	Herb
49	*Hyptis suaveolens* (L.) Poit.	Herb
50	*Jatropha gossypifolia* L.	Shrub
51	*Kalanchoe pinnata* (Lam.) Pers.	Herb
52	*Lantana camara* L.	Scandent Shrub
53	*Ledebouria kirkii* (Baker) Stedje & Thulin	Herb
54	*Leucaena leucocephala* (Lam.) de Wit	Shrubby Tree
55	*Limnocharis flava* (L.) Buchenau	Aquatic Herb
56	*Ludwigia hyssopifolia* (G. Don.) Exell	Aquatic Herb
57	*Ludwigia octovalvis* (Jacq.) P.H.Raven	Aquatic Herb
58	*Malvastrum coromandelianum* (L.) Garcke	Herb
59	*Manihot esculenta* Crantz	Shrub
60	*Melinis repens* (Willd.) Ziska	Grass
61	*Mikania micrathan* (L.) Kunth	Herbaceous Climber
62	*Mimosa diplotricha* C. Wright ex Sauvalle	Herb
63	*Mimosa pigra* L.	Shrub
64	*Mimosa pudica* L.	Creeping Herb
65	*Mitracarpus hirtus* DC.	Herb
66	*Muntingia calabura* L.	Shrubby Tree
67	*Nymphaea capensis* Thunb. var. *zanzibariensis* Casp.	Aquatic Herb
68	*Opuntia elatior* Mill.	Shrub
69	*Oxalis corniculata* L.	Creeping Herb
70	*Panicum meximum* Jacq.	Grass
71	*Passiflora foetida* L.	Herbaceous Climber
72	*Pennisetum pedicellatum* Trin.	Grass
73	*Pennisetum polystachyon* (L.) Schult.	Grass
74	*Pennisetum purpureum* Schumach.	Grass
75	*Phaseolus atropurpureus* Moc. et Sesse ex DC.	Herbaceous Climber
76	*Phaseolus lathyroides* L.	Herb
77	*Phyla nodiflora* (L.) Greene	Creeping Herb
78	*Phyllanthus amarus* Schumch. & Thonn.	Herb
79	*Physalis angulata* L.	Herb

No.	Botanical Name	Habit
80	*Pilea microphylla* (L.) Liebm.	Herb
81	*Pithecellobium dulce* (Roxb.) Benth.	Tree
82	*Praxelis clematidea* (Griseb.) R.M. King & H. Rob.	Herb
83	*Psidium guajava* L.	Tree
84	*Ruellia tuberosa* L.	Herb
85	*Samanea saman* (Jacq.) Merr.	Tree
86	*Scoparia dulcis* L.	Herb
87	*Senna alata* (L.) Roxb.	Shrub
88	*Senna occidentalis* (L.) Link	Herb
89	*Senna tora* (L.) Roxb.	Undershrub
90	*Setaria verticillata* (L.) P. Beauv..	Grass
91	*Sida acuta* Burm. f.	Undershrub
92	*Solanum nigrum* L.	Herb
93	*Solanum aculeatissimum* Jacq.	Shrub
94	*Solanum stramonifolium* Jacq.	Shrub
95	*Solanum torvum* Sw.	Shrub
96	*Spathodea campanulata* P.Beauv.	Tree
97	*Spermacoce laevis* Roxb.	Herb
98	*Sphagneticola trilobata* (L.) Pruski	Creeping Herb
99	*Stachytarpheta indica* (L.) Vahl.	US : Tro. Am.
100	*Stylosanthes guianensis* (Aubl.) Sw.	Herb
101	*Synedrella nodiflora* (L.) Gaertn.	Herb
102	*Tagetes patula* L.	Herb
103	*Talinum paniculatum* (Jacq.) Gaertn.	Herb
104	*Tamarindus indica* L.	Tree
105	*Tecoma stans* (L.) Kunth	Shrub
106	*Tithonia diversifolia* (Hemsl.) A.Gray	Undershrub
107	*Tradescantia zebrina* Heynh.	Herb
108	*Tridax procumbens* L.	Herb
109	*Typha angustifolia* L.	Aquatic Herb
110	*Zoysia matrella* (L.) Merr.	Grass

Annex 3 Target forest tree species included in ex situ conservation program

No.	Botanical Name	Thai name	Native or Exotic	Type of uses
1	*Acacia auriculiformis* A.Cunn. ex Benth	Kra thin narong	E	Economy
2	*Acacia mangium* Willd.	Kra thin te pha	E	Economy
3	*Adenanthera pavonina* L.	Ma klam ton	N	Economy
4	*Afzelia xylocarpa* (Kurz) Craib	Ma kha mong	N	Economy
5	*Alstonia scholaris* (L.) R.Br.	Tin pet	N	Economy
6	*Anthocephalus chinensis* (Lam.) A.Rich ex Walp.	Taku	N	Economy
7	*Aquilaria malaccensis* Lam.	Kritsana	N	Non-Wood Forest Product
8	*Artocarpus altilis* (Parkinson) Fosberg	Sake	N	Non-Wood Forest Product
9	*Artocarpus lacucha* Roxb.	Mahat	N	Non-Wood Forest Product
10	*Artocarpus lanceifolius* Roxb.	Khanun pa	N	Non-Wood Forest Product
11	*Azadirachta indica* A.Juss. var. *indica*	Sadao India	N	Economy
12	*Azardirachta excelsa* (Jack) Jacobs	Sadao thiam	E	Economy
13	*Senna siamea* (Lam.) Irwin & Barneby	Khilek ban	N	Non-Wood Forest Product
14	*Casuarina equisetifolia* J.R. & G.Forst.	Son thale	N	Economy
15	*Casuarina junghuhniana* Miq.	Son pradi phat	E	Economy
16	*Chukrasia tabularis* A.Juss.	Yomhin	N	Economy
17	*Chukrasia velutina* (M.Roem.) C.DC.	-	N	Economy
18	*Cinnamomum porrectum* (Roxb.) Kosterm.	Thep tharo	N	Non-Wood Forest Product
19	*Cotylelobium melanoxylon* (Hook.f.)Pierre	Khiam	N	Economy
20	*Dalbergia cochinchinensis* Pierre	Pha yung	N	Economy
21	*Dalbergia oliveri* Gamble	Chingchan	N	Economy
22	*Dipterocarpus alatus* Roxb. ex G.Don	Yang na	N	Economy
23	*Eucalyptus camaldulensis* Dehnh.	Yukhaliptus camaldulensis	E	Economy/ Non-Wood Forest Product
24	*Eucalyptus urophylla* S.T.Blake	Yukhaliptus urophylla	E	Economy

No.	Botanical Name	Thai name	Native or Exotic	Type of uses
25	*Eugenia grandis* Wight	Cha mao	N	Non-Wood Forest Product
26	*Fagraea fragrans* Roxb.	Kan krao	N	Economy
27	*Gluta laccifera* (Pierre) Ding Hou	Nam kliang	N	Non-Wood Forest Product
28	*Gluta usitata* (Wall.) Ding Hou	Rak yai	N	Non-Wood Forest Product
29	*Gmelina arborea* Roxb.	So	N	Economy
30	*Hopea odorata* Roxb.	Ta khian thong	N	Economy
31	*Intsia palembanica* Miq.	Lum pho	N	Economy
32	*Magnolia sirindhorniae* Noot. & Chalermklin	Champi sirinthon	N	Non-Wood Forest Product
33	*Mangifera caloneura* Kurz	Mamuang pa	N	Non-Wood Forest Product
34	*Mangifera quadrifida* Jack.	Mamuang khan	N	Non-Wood Forest Product
35	*Melia azedarach* L.	Lian	N	Economy
36	*Palaquium obovatum* (Griff.) Engl.	Khanun nok	N	Economy
37	*Parashorea stellata* Kurz	Khai khiao	N	Economy
38	*Parkia timoriana* Lam.	Riang	N	Non-Wood Forest Product
39	*Parkia speciosa* Hassk.	Sato	N	Non-Wood Forest Product
40	*Phyllanthus emblica* L.	Ma kham pom	N	Non-Wood Forest Product
41	*Pinus caribaea* Morelet	Son caribae	E	Economy
42	*Pinus kesiya* Royle ex Gordon	Son sam bai	N	Economy
43	*Pinus merkusii* Jungh. & de Vriese	Son song bai	N	Economy
44	*Pterocarpus macrocarpus* Kurz	Pradu	N	Economy
45	*Rhus succedanea* L.	Kaen mo	N	Non-Wood Forest Product
46	*Sandoricum koetjape* (Burm.f.) Merr.	Kha thon	N	Non-Wood Forest Product
47	*Scaphium scaphigerum* (G.Don) Guib. & Planch.	Samrong	N	Non-Wood Forest Product
48	*Shorea henryana* Pierre	Khiam khanong	N	Economy
49	*Shorea roxberghii* G.Don	Phayom	N	Economy
50	*Sterculia foetida* L.	Samrong	N	Economy/ Non-Wood

No.	**Botanical Name**	**Thai name**	**Native or Exotic**	**Type of uses**
				Forest Product
51	*Syzygium cumini* (L.) Skeels	Wa	N	Non-Wood Forest Product
52	*Tectona grandis* L.f.	Sak	N	Economy
53	*Terminalia bellerica* (Gaertn.) Roxb.	Samor phi phek	N	Non-Wood Forest Product
54	*Toona ciliata* M.Roem.	Yom hom	N	Economy
55	*Vernicia montana* Lour.	Ma yao hin	N	Non-Wood Forest Product
56	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	Daeng	N	Economy

Annex 4 List of *ex situ* conservation in the form of improved seed stand (seed production area- SPA, provenance seed stand- PSS and seed orchard- SO covering an areas of 1,162 ha

No.	Botanical Name	Improved Seed Stand
1	*Acacia* spp.	SO, PSS
2	*Acacia auriculiformis* A.Cunn. ex Benth	SO
3	*Acacia mangium* Willd.	SO, PSS
4	*Afzelia xylocarpa* (Kurz) Craib	PSS
5	*Alstonia scholaris* (L.) R.Br.	SPA
6	*Azadirachta indica* A.Juss.	PSS
7	*Azadirachta excelsa* (Jack) Jacobs	SPA
8	Bamboo	SPA
9	*Calamus* spp.	SPA
10	*Casuarina junghuhniana* Miq.	SO, PSS, SPA
11	*Chukrasia velutina* (M.Roem.) C.DC.	PSS
12	*Dalbergia cochinchinensis* Pierre	PSS, SPA
13	*Dipterocarpus alatus* Roxb. ex G.Don	PSS
14	*Eucalyptus* spp.	SO, PSS, SPA
15	*Eucalyptus camaldulensis* Dehnh.	SO, PSS
16	*Fagraea fragrans* Roxb.	PSS
17	*Gmelina arborea* Roxb.	SPA
18	*Hopea odorata* Roxb.	SPA
19	*Khaya senegalensis* (Desr.) A. Juss.	SPA
20	*Melia azedarach* L.	SPA
21	*Parashorea stellata* Kurz	SPA
22	*Pinus caribaea* Morelet	SO, PSS, SPA
23	*Pinus* spp.	SO, PSS
24	*Pterocarpus macrocarpus* Kurz	PSS
25	*Tectona grandis* L.f.	SO, PSS, SPA
26	*Toona ciliate* M.Roem.	SPA
27	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	PSS

Annex 5 *Ex situ* conservation plots (ha) and plus trees (+) of indigenous species (adapted from FORGENMAP 2002a)

Species	Site 1		2		3		4		5		Total per species	
	ha	+	ha	+	ha	+	ha	+	ha	+	ha	+
Dipterocarpus alatus Roxb. ex G.Don	16	30	26	14	10	-	10	-	-	-	52	44
Dalbergia cochinchinensis Pierre	16	25	10	-	10	-	10	-	10	13	56	38
Xylia xylocarpa kerrii (Roxb.) Taub.	20	30	10	30	10	-	-	-	10	25	50	85
Pterocarpus macrocarpus Kurz	16	25	10	30	10	-	-	-	10	26	46	81
Shorea roxburghii G.Don	16	25	10	-	10	-	-	-	-	-	36	25
Afzelia xylocarpa (Kurz) Craib	16	25	4	-	10	-	-	-	10	28	40	53
Dalbergia oliveri Gamble	20	30	4	-	10	-	-	-	-	-	34	30
Hopea odorata Roxb.	16	25	26	5	10	-	-	-	-	-	42	30
Total											**356**	**386**

Sites: (1) Kampangphet Sivicultural Research Station, Kampangphet, (2) Sakaerat Sivicultural Research Station, Nakhonratchasima, (3) Nongku Sivicultural Research Station, Surin, (4) Ubonratchatani Sivicultural Research Station, Ubonratchatani, (5) Central Sivicultural Research Center, Kanchanaburi.

Annex 6 Plus trees of 3 670 plus trees selected from over 70 species of both native and exotic in natural forest and plantation

No.	Botanical Name	No.	Botanical Name
1	*Acacia auriculiformis* A.Cunn. ex Benth	36	*Eucalyptus paniculata* Sm.
2	*Acacia aulacocarpa* A.Cunn.ex Benth	37	*Eucalyptus pellita* F Muell.
3	*Acacia auriculaeformis* A.Cunn. ex Benth	38	*Eucalyptus propinqua* H.Deane & Maiden
4	*Acacia cincinnata* F Muell.	39	*Eucalyptus punctata* DC.
5	*Acacia crassicarpa* A.Cunn.ex Benth	40	*Eucalyptus raveretiana* F Muell.
6	*Acacia flavescens* A.Cunn.ex Benth	41	*Eucalyptus resiniferra* Smith
7	*Acacia hylonoma* Pedley	42	*Eucalyptus torelliana* F Muell.
8	*Acacia leptocarpa* A.Cunn.ex Benth	43	*Eucalyptus tereticornis* Sm.
9	*Acacia mangium* Willd.	44	*Eucalyptus urophylla* S.T.Blake
10	*Acacia oraria* F Muell.	45	*Eucalyptus grandis* W.Hill ex Maiden
11	*Acacia polystachya* A.Cunn.ex Benth	46	*Gluta usitata* (Wall.) Ding Hou
12	*Acacia shirleyi* Maiden	47	*Gmelina arborea* Roxb.
13	*Alstonia scholaris* (L.) R.Br.	48	*Hopea odorata* Roxb.
14	*Azadirachta excelsa* (Jack) Jacobs	49	*Khaya senegalensis* (Desr.) A. Juss.
15	*Afzelia xylocarpa* (Kurz) Craib	50	*Mangifera caloneura* Kurz
16	*Albizia procera* (Roxb.) Benth.	51	*Melia azedarach* L.
17	*Allocasuarina littoralis* (Salisb.) L. Johnson	52	*Melaleuca bracteata* F Muell.
18	*Azadirachta indica* A.Juss. var. *siamensis* Valeton	53	*Melaleuca cajuputi* Powell
19	*Casuarina cunninghamiana* Miq	54	*Melaleuca dealbata* S.T.Blake
20	*Casuaina junghuhniana* Miq.	55	*Melaleuca symhyocarpa* F Muell.
21	*Chukrasia velutina* (M.Roem.) C.DC.	56	*Melaleuca viridiflora* Sol. ex Gaertner
22	*Cotylelobium melanoxylon* (Hook.f.)	57	*Pinus caribaea* Morelet
23	*Dipterocarpus alatus* Roxb. ex G.Don	58	*Pinus kesiya* Royle ex Gordon
24	*Dipterocarpun turbinatus* C.F.Gaertn.	59	*Pinus oocarpa* Schiede
25	*Dalbergia cochinchinensis* Pierre	60	*Pinus tecunumanii* Eguiluz & J. P. Perry
26	*Dalbergia oliveri* Gamble	61	*Peltophorum pterocapum* (DC.) Backer ex K.Heyne
27	*Dipterocarpus tuberculatus* Roxb.	62	*Pterocarpus macrocarpus* Kurz
28	*Eucalyptus alba* Blume	63	*Shorea roxburghii* G.Don
29	*Eucalyptus barsciana* S.T. Blake	64	*Shorea siamensis* Miq.
30	*Eucalyptus camaldulensis* Dehnh.	65	*Shorea obtusa* Wall. ex Blume
31	*Eucalyptus citriodora* Hook.	66	*Toona ciliata* M.Roem.
32	*Eucalyptus cloeziana* F Muell.	67	*Tectona grandis* L.f.
33	*Eucalyptus houseana* Maiden	68	*Terminalia arenicola* Byrnes
34	*Eucalyptus microcorys* F Muell.	69	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen
35	*Dalbergia cochinchinensis* Pierre		

Department of National Parks, Wildlife and Plant Conservation
61 Phahonyothin Road, Ladyaow, Jatuchak, Bangkok 10900
THAILAND